IMPRINT Workshop

IMPRINT Team

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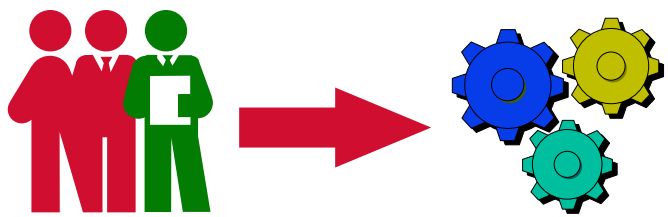
What is IMPRINT?

(Improved Performance Research Integration Tool)

- Army-developed soldier-system analysis tool
  - For predicting the effects of manpower, personnel, & training (MPT) on system effectiveness
  - Using or adapting best available methods
  - And best available data
  - For diverse users - analysts & researchers
  - To support design, acquisition, & assessment today



What Does IMPRINT Do?

It helps you...

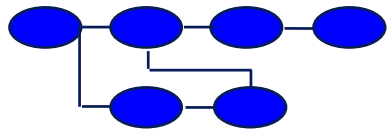
- Set realistic system requirements
- Identify future manpower & personnel constraints
- Evaluate operator & crew workload
- Test alternate system-crew function allocations
- Assess required maintenance manhours
- Assess performance under extreme conditions
- Examine performance as a function of personnel characteristics, training frequency & recency
- etc.

How Does IMPRINT Do It?

- Stochastic task network modeling
  - Build your own mission model

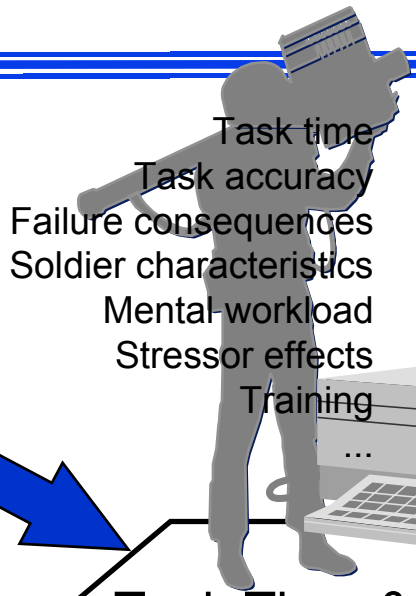
    time, accuracy, task type, failure…
  - Parameterize maintenance model

    MTTR, MOUBF, combat damage, rounds fired…



- Workload modeling: VACP & Advanced
- Performance shaping functions & stressors
- Manpower projection
- Access data libraries: System & soldier data
- Force-level roll-up

IMPRINT Architecture



Unit & Force

Task Libraries

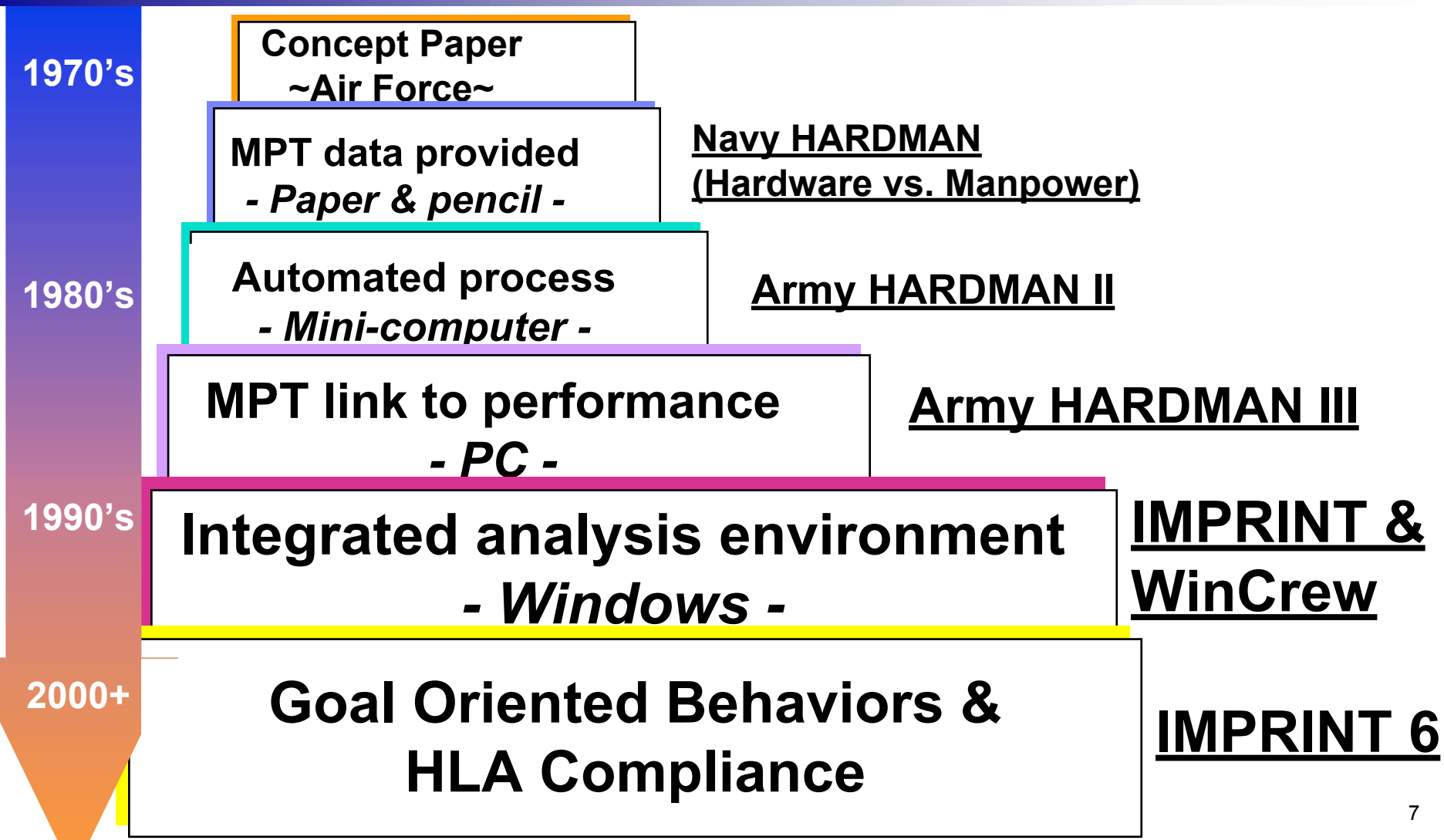
System Measures

Task Time & Error Data - Estimates & Requirements

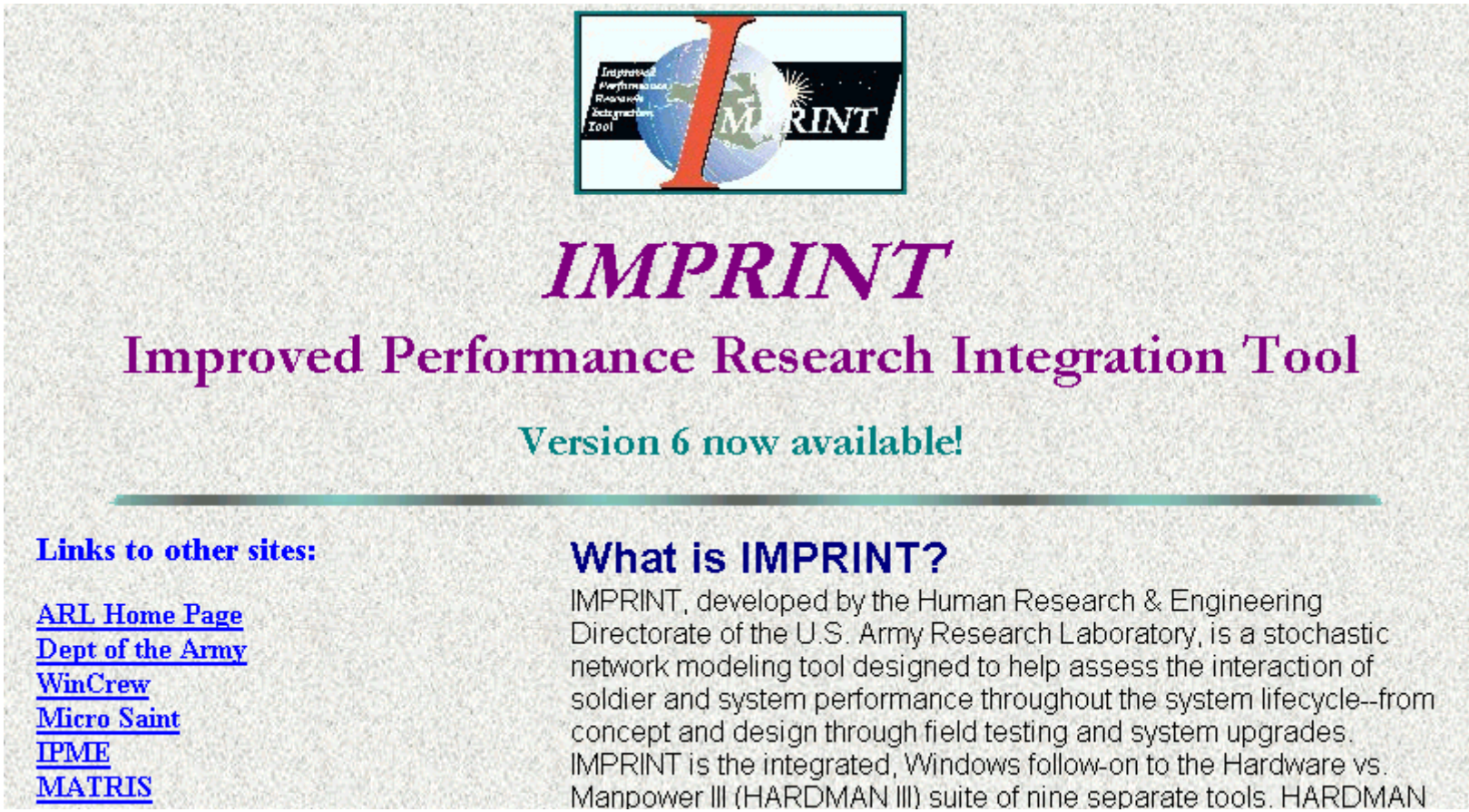
Soldier Data
Workload
Future Manpower
Stressors...

Model

IMPRINT: Evolution & Revolution



IMPRINT Web Page



IMPRINT

Improved Performance Research Integration Tool

Version 6 now available!

Links to other sites:

ARL Home Page
Dept of the Army
WinCrew
Micro Saint
IPME
MATRIS

What is IMPRINT?

IMPRINT, developed by the Human Research & Engineering Directorate of the U.S. Army Research Laboratory, is a stochastic network modeling tool designed to help assess the interaction of soldier and system performance throughout the system lifecycle--from concept and design through field testing and system upgrades. IMPRINT is the integrated, Windows follow-on to the Hardware vs. Manpower III (HARDMAN III) suite of nine separate tools. HARDMAN

http://www.arl.army.mil/ARL-Directorates/HRED/imb/imprint/imprint.htm

IMPRINT Verification, Validation & Accreditation

- Per AR 5-11, Army Model and Simulation Management Program
- Accreditation Board
  - ADCSPER, Chair & Members representing policy, users, testers, materiel developers, decision makers
- Effort completed 2QF 95 -
  - Define Mission, VACP, PTS
- IMPRINT is a tool for building models & includes embedded models!
- VV&A may be required for user-developed models

Extra Benefits of Doing V&V

- It's a great way to debug software
- It drives you to document model assumptions and limits
- It goes hand in hand with configuration management
- It helps build toward model standards, data sharing, etc.
- It's a way to reduce system risk
- If you do it right in the beginning, the "savings" are realized throughout the life-cycle
- It helps you develop rapport with the customer
- It helps build credibility for human performance modeling across the board!

Who Has IMPRINT?

Army	77
Navy	13
Air Force	8
Other Government	2
Contractors	83
University	12

- 195 and growing!

IMPRINT: Some Applications

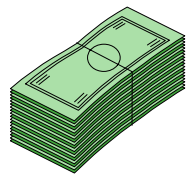
- Fox NBC Reconnais-sance Vehicle → Reduced crew: workload & performance
- Special Forces Joint Base Station → Reduced crew: workload & skill
- Crusader → Crew size & CONOPS
- Job Consolidation for Army Ordnance MOSs → Maintenance & availability; manning
- Air Warrior → Performance degradation

Fox NBC Reconnaissance Vehicle

- Crew size reduced from 4 to 3
- Crew gender
- But design retained 4 stations

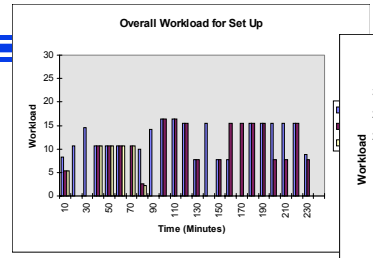
And performance was unacceptable!

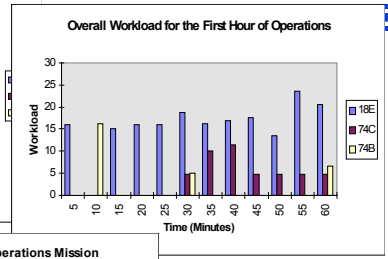
- Predicted performance improvement with simple design change
  - ➢ Reduced workload
  - ➢ Shortened mission duration
  - ➢ Reduced soldier risk
- Re-designed system validated with minimum of testing
- Performance now acceptable!
- *$2-4M saved in program costs*
- *25% soldier costs over 20 year lifecycle*

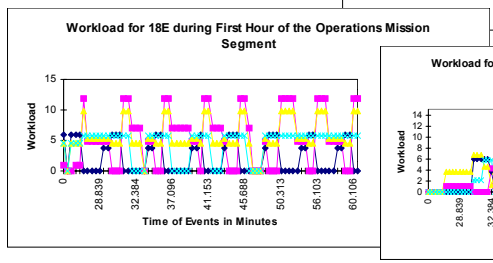


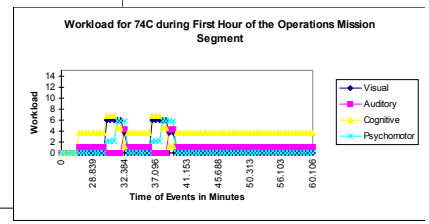
Joint Base Station

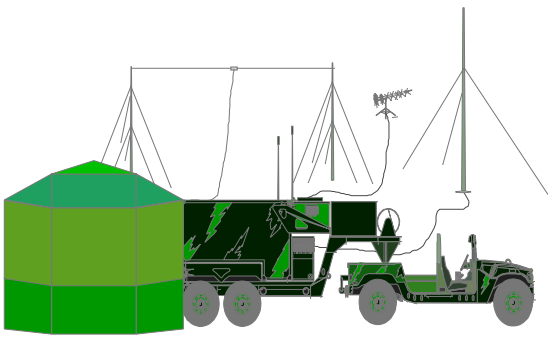
- Special Forces Com Center
- Adding automation
- New job specialty (MOS) required?



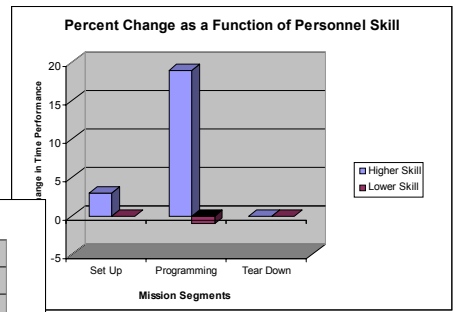


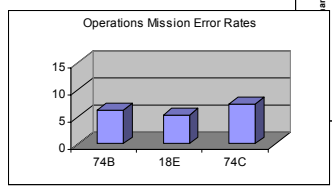






- Model for crew workload
- Check performance with different soldier skill levels





- Either different MOS or increase training
- *Recommend different MOS for automation equipment*

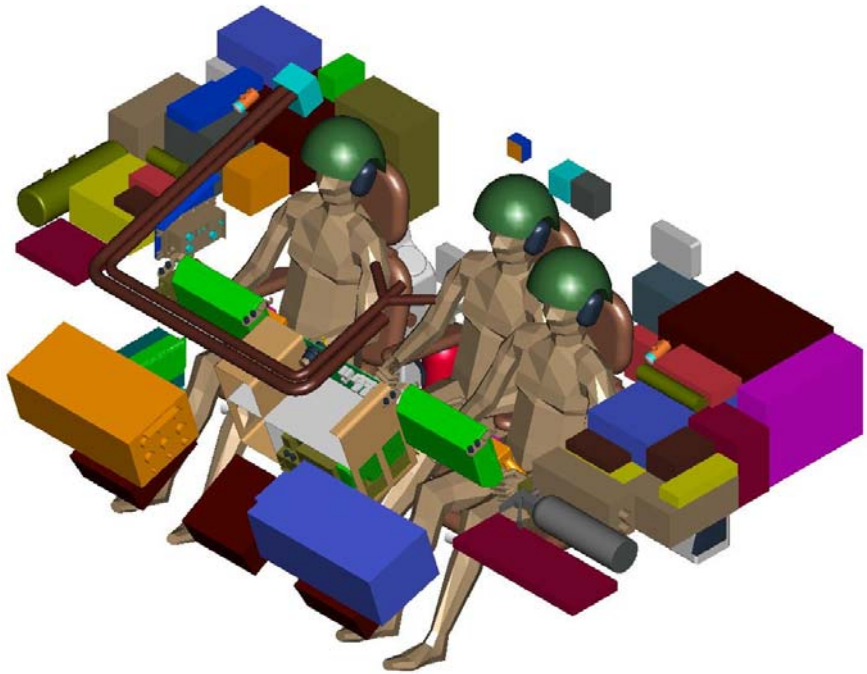
Crusader - Advanced Field Artillery System

Early Modeling Predictions

> 2-man crew: 6% more time, 80% more errors than 3-man crew

> Auto upload required

> 40% more errors after 48 hrs even with 3-man crew



- As design matures, re-examining issues
  - crew size
  - crew-equipment match
  - extended operations

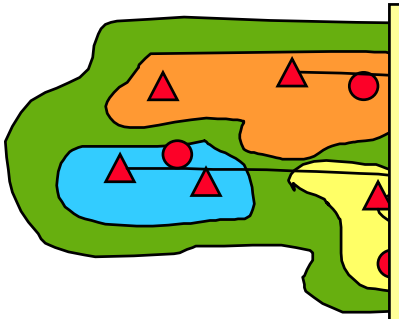
Modeling Predictions for Current Design & Manning Decisions

> Even with updated design & scenario, 2-man crew: 8% more time

	Mission Capability	
	3-man crew	2-man crew
Day 1	92%	55%
Day 2	66%	2%
Day 3	0%	0%

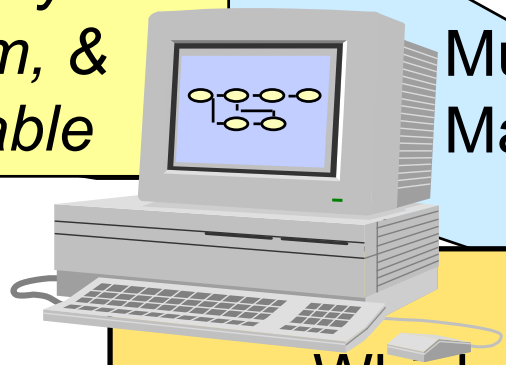
Modeling MOS Consolidation for Unit Design

From: Fixed maintenance levels
Rear maintenance...



IMPRINT Models Baseline, System Subsystem, & Multi-capable

To: Fix forward
Multi-capable mechanic
Maintenance enablers

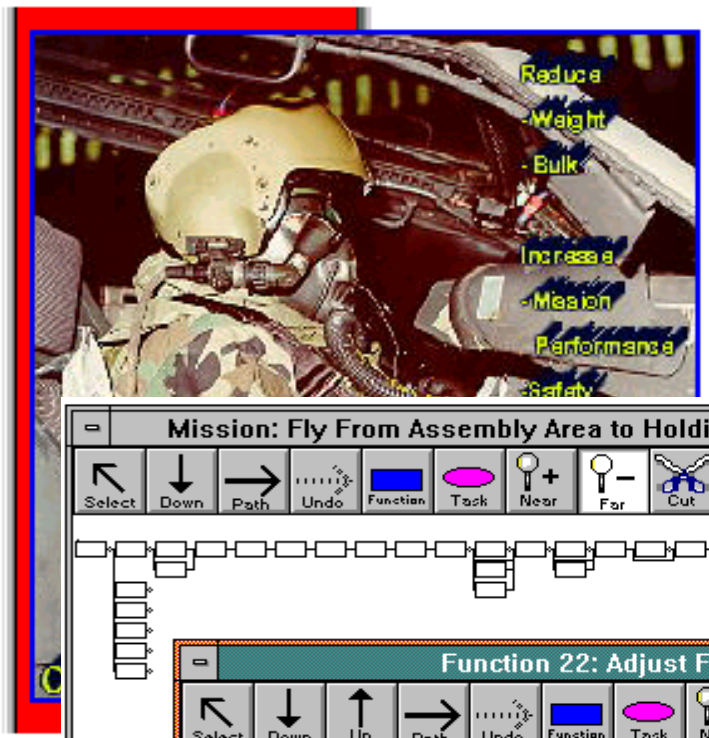


Designed & evaluated early via task data; org structures; available manning, skills & abilities; system-mission priorities

USAOC&S Question:
Which consolidation concept gives greatest OA with lowest cost?

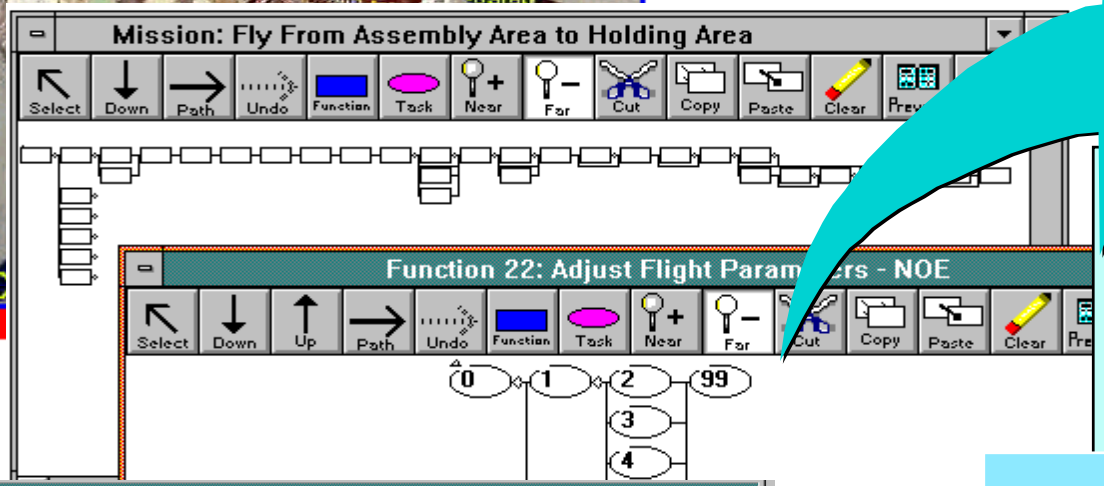
Army of Excellence → Force XXI → Army After Next

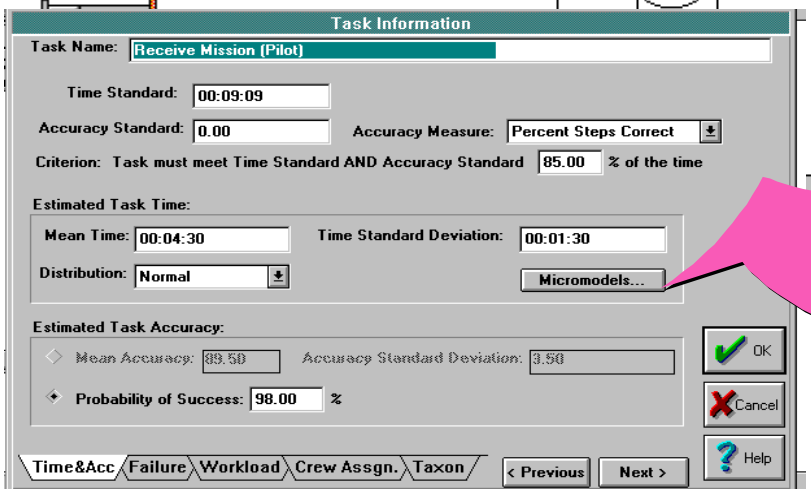
IMPRINT Modeling & Degraded Performance Factors for Air Warrior

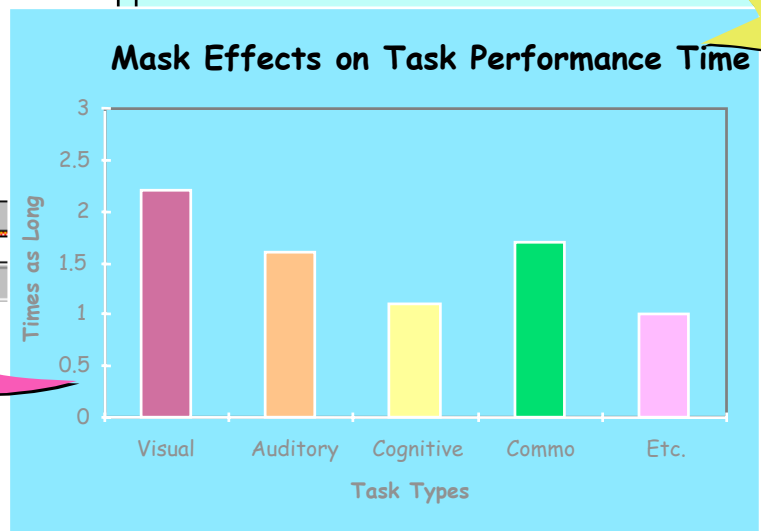


System Performance Effects

Questionnaire







Model Input

Overview of Analysis Steps & IMPRINT Structure

Steps in an IMPRINT Analysis

- *The same steps as in any good analysis*

1. Define objectives
2. Define the budget
3. Design the study
4. "Collect" baseline input data
5. "Develop" the task data
6. Build the model
7. Debug the model
8. "Run" the study
9. "Collect" output data
10. Analyze data
11. Present the results!

Help in Defining the Objectives

Improved Performance Research Integration Tool (IMPRINT)

User's Guide

Version 6.0

July 2002

US Army Research Laboratory
Human Research and Engineering Directorate

DRAFT

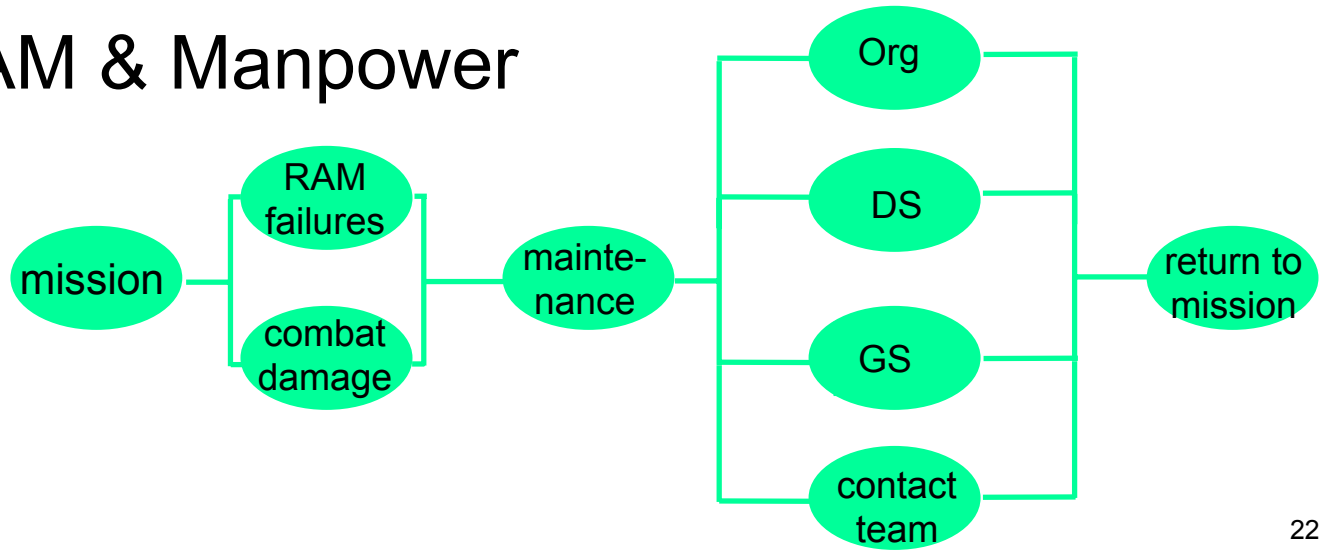
Table of Contents

Define Mission

- Decompose Function & Task Networks
- Input Standards
- Input Task Time - Mean & Standard Deviation
- Option: Input Task Accuracy
- Other Options: ★
  - mental workload
  - Army Military Occupational Specialty assignment
  - taxon descriptors to enable stressors & performance shaping functions
- Execute Model & Task Data are Aggregated up to Function- & Mission-level Estimates

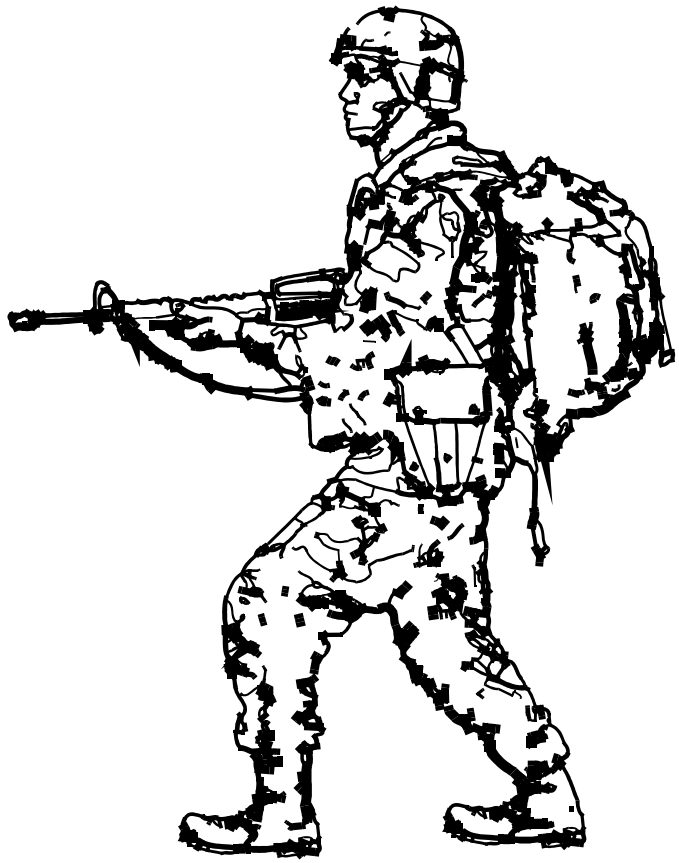
Define Equipment

- Identify Subsystems & Components w/ Associated Data
  - MOS, MTTR, MOUBF, tasks, maintenance level, etc.
- Build Scenario with Usage Rates
  - number of systems required for mission, shift length, rounds, miles, hours operational, etc.
- System RAM & Manpower



Define Soldiers

- Army Military Occupational Specialties
- Identified by job title
- Linked to descriptive data
- Capability to project future manpower levels



Define Force

- Army Force Structure information
- Army-wide roll-ups of single system & unit analyses

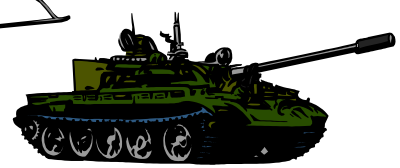


Define Supply

- Fuel & ammunition information
- Calculates number of transporters & the manpower required to support scenarios created under Define Equipment





Options

- Workload options
- Personnel characteristics
- Training
- Environmental stressors
  - heat, cold, noise, protective clothing, hours since last sleep
- Accessing data in spreadsheet format

Loading the Software

System Requirements

Desired

- Pentium
- 64 MB RAM - Minimum
- 100 MB disk space
- VGA
- Windows 95/98 or Windows NT/2000
- Office for enhanced reporting & graphing

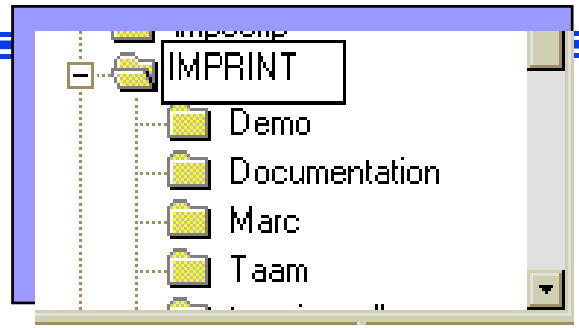
Installing IMPRINT

- Installs from CD to hard drive
- Installation procedure determine the correct DLLs to install
- Default directory: C:\IMPRINT

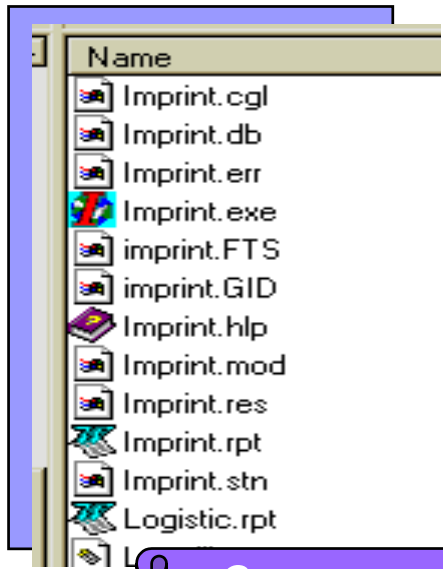
Install

Starting & Stopping Your Analysis

The IMPRINT Directory



- What's in it
  - Executable files, & DLL files
  - IMPRINT database files
    - » "library" files - stuff that "comes with" IMPRINT
    - » "user" files - your stuff
    - » "working" or "session" files - for the open analysis
  - Report files - linked to an analysis
  - Help files
  - Documentation & Readme
    - » Analysis Guide & User's Guide
- What isn't: Your analysis by name!



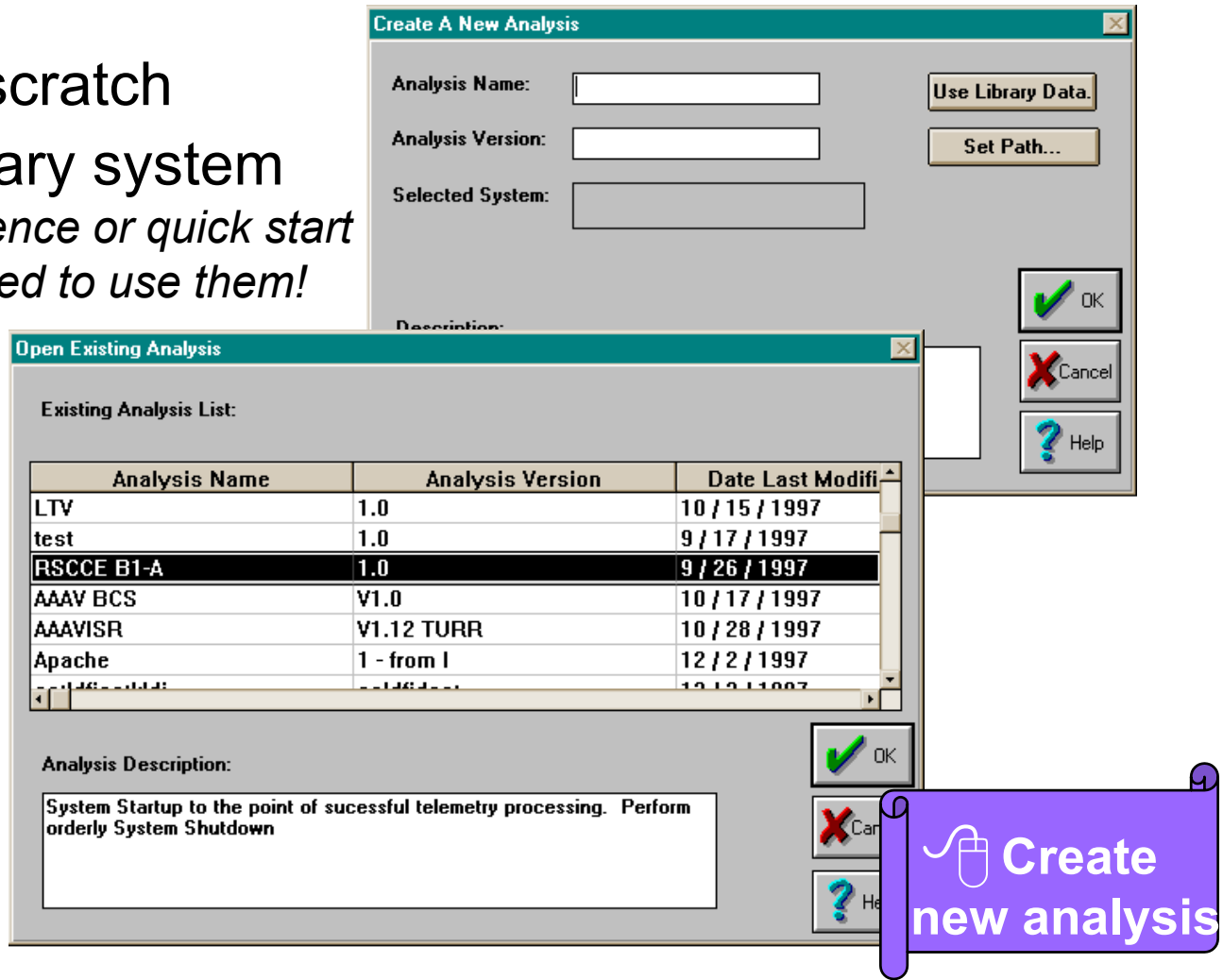
Look & Open docs

What Your Analysis Looks Like

- When you open IMPRINT, you will create a new analysis
  - Starting from scratch
  - Or using a library system

  Libraries are for reference or quick start
  But you are not required to use them!

- Or open an existing one



The IMPRINT Library (& New User Models)

Mission Area	System Type	System
Air Defense	Air Defense Mobile Gun	M163 VULC
Air Defense	HIMAD	Patriot FP
Air Defense	Man-port Air Defense Sys	STINGER
Aviation	Attack Helicopter	AH-64A
Aviation	Cargo Helicopter	CH-47D
Aviation	Scout Helicopter	OH-58D
Aviation	Utility Helicopter	UH-60A
Close Combat Heavy	Cavalry Fighting Vehicle	M3 BRADLEY
Close Combat Heavy	Tank	M1 ABRAMS
Close Combat Light	Anti-tank Vehicle	M901 ITV
Close Combat Light	Automatic Weapon	M249 SAW
Close Combat Light	Grenade Launcher	M203
Close Combat Light	Infantry Fighting Vehicle	M2 BRADLEY
Close Combat Light	Man-port. Anti-tank Wp	DRAGON
Close Combat Light	Man-port Indirect Fire Wp	M252 81MM
Close Combat Light	Rifle	M16A1
Combat Service Support	Heavy Truck	M977 HEMTT
Combat Service Support	Light Truck	M998 HMMWV
Fire Support	Med Range Missile Artill'y	LANCE
Fire Support	Rocket Field Artill'y System	MLRS
Fire Support	Self-propelled Howitzer	M109A2 HOW
Fire Support	Towed Howitzer	M102 HOW

OK

Cancel

?

Plus new user-developed models for IMPRINT:

LW155
AAAV
Fox
Comanche
Longbow
Crusader
JBS
HMD
...

Embedded data include: task network, task times, workload, repair & failure times, soldier skill etc.

Navigating within IMPRINT

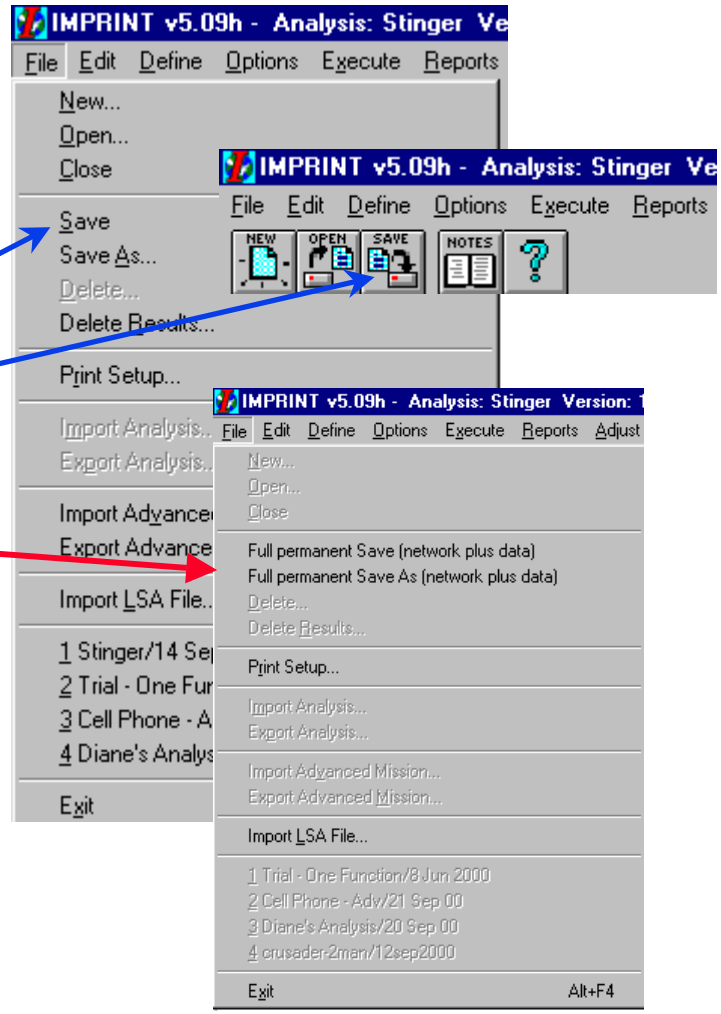
- Windows “standards” (to the extent possible)
  - OK goes back one and saves
  - Cancel also goes back one & does not save
  - Other buttons advance
- Deeply embedded windows
  - Navigate from top > down
  - At embedded levels, also navigate sideways
- Multiple ways to access data
  - Lists, graphics, spreadsheets

Saving Your Analysis

- Save early, save often*
  *from the top-most window
- Save again as you exit

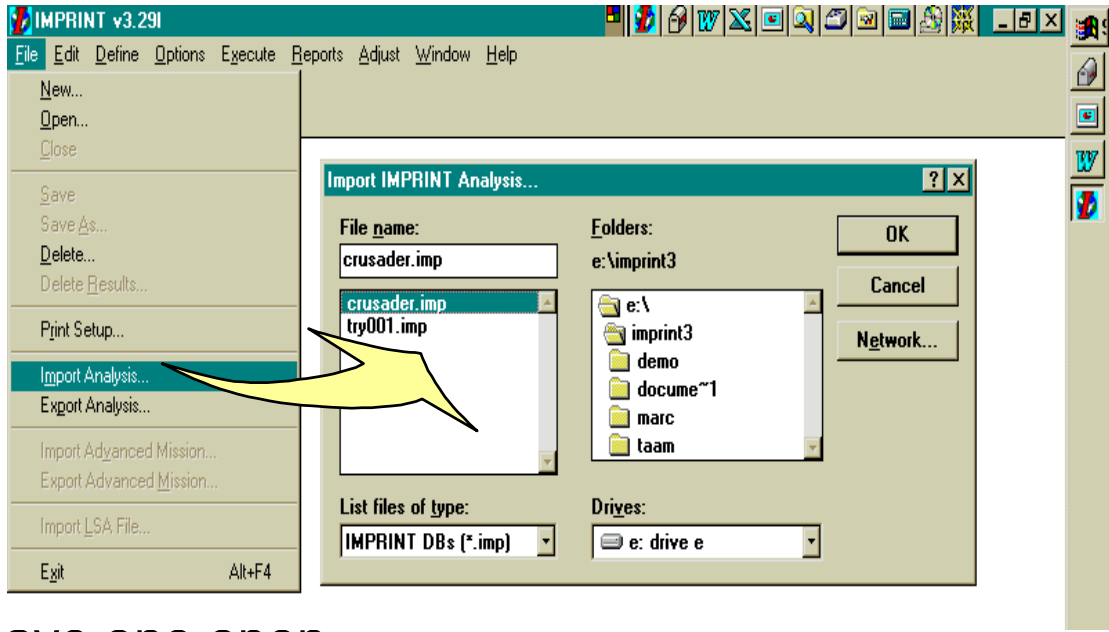
- Saving your analysis
- Saving your network diagram & information

- When in doubt, save
- Reminders are legitimate!



Sharing Your Analysis Using Import & Export

- To Import -
  - Close the open analysis
  - Select “Import”
  - Browse until you find the one you’re looking for
  - To access the analysis, you must then open it



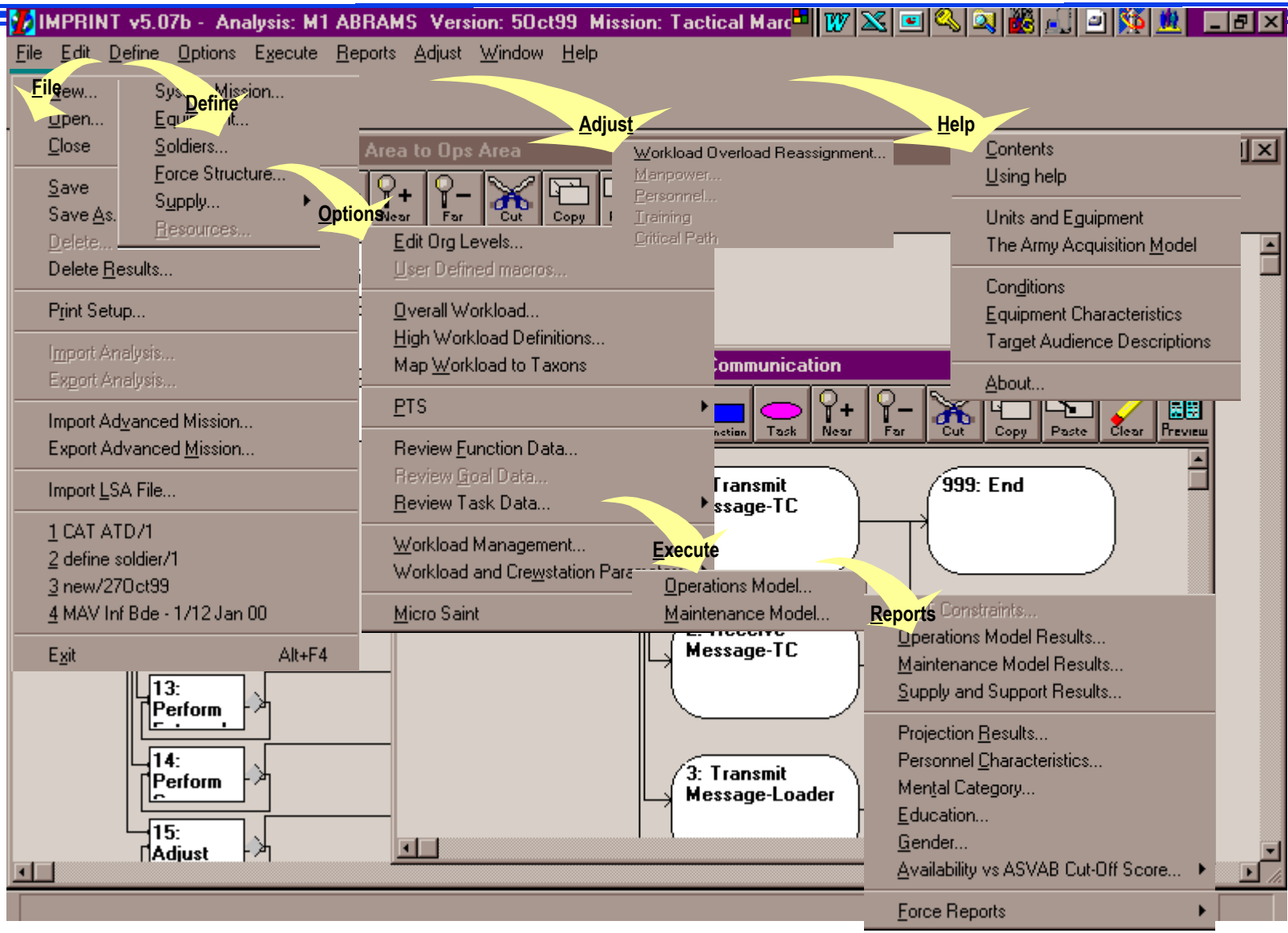
- To Export -
  - Close your analysis if you have one open
  - Select Export option
  - Create export file using Windows naming conventions
  - On hard drive or on disk
  - File name <u>does not have to</u> = analysis name

Will start by importing

Special Case for Import & Export of Advanced Missions to Other Tools--i.e., WinCrew

In IMPRINT, it’s an analysis. Out of IMPRINT, it’s a .imp file.

IMPRINT Menus



IMPRINT Reports

Maintainer

Maintenance Model Reports

Scenario: Ten Days of Missions

Select the reports you wish to view:

- Maintenance Summary
- Daily Maintenance
- Reliability and Availability
- Maintenance Hit Matrix
- Daily Reliability

Maintenance Summary

Scenario	0	Ten Days of Missions
Total Operating Hours		3,200.00
Average Preventive Maintenance Hours		308.42
Average Corrective Maintenance Hours		8.93
Average Maintenance Per Operating Hour		0.10

Daily Maintenance

Day	Preventive	Corrective
1	25.91	1.21
2	21.59	0.07
3	7.92	1.0
4	20.09	1.2
5	14.80	1.2
6	10.31	0.2
7	27.94	0.2

Reliability and Availability

Availability Summary

Average Inherent Availability	99.95 %
Average Achieved Availability	99.29 %
Readiness	100.00 %

Maintenance Hit Matrix

Task Name	Type of Maint.	Level	MOS 1	No.	MOS 2	No.	Occurences	ManHours
Remove & Replace	Preventive	ORG	68N20	2	67T20	1	14	10.50
Trouble Shoot	Preventive	ORG	68N20	1	68F20	1	5	3.30
Adjust & Repair	Preventive	ORG	68F20	1	67T20	1	1	0.26
Remove & Replace	Preventive	ORG	68N20	2	67T20	1	7	3.04
Trouble Shoot	Preventive	ORG	68N20	2	67T20	1	4	1.20
Adjust & Repair	Preventive	ORG	68N20	2	68F20	1	4	9.72
Adjust & Repair	Preventive	ORG	67T20	2	68N20	1	12	9.72
Remove & Replace	Preventive	ORG	67T20	2	68N20	1	25	18.00

Operator

Mission Performance

Mission 56 Fly from Landing Zone (LZ) to Pickup Zone (PZ)

Number of Times Performed: 10

	Standard	Minimum	Maximum	Mean	Standard Deviation	% Met
Time <=	00:42:00	00:29:05	00:30:33	00:29:40	00:00:26	100.00
Accuracy:						
Mission Time						
RESULT:						

Task Performance

RESULT: This does NOT meet the performance criterion of 85.00%.

Function: 9 Initiate Level Flight (LZ - PZ)

Task 2 Adjust Power

Operator Name: Pilot

Number of times performed: 10

	Standard	Minimum	Maximum	Mean	Std. Dev.	% Met
Time <=	00:00:04	00:00:01	00:00:01	00:00:01	00:00:00	100.00

Operator Workload

Operator	Time (Min)	Visual	Auditory	Cognitive	Psychomotor	Number
Pilot	0.000	1.00	1.00	4.70	0.00	2.00
Pilot	0.020	1.00	1.00	4.70	0.00	2.00
Pilot	0.030	1.00	5.90	10.00	0.00	3.00
	0.050	1.00	5.90	10.00	0.00	3.00
	0.060	0.00	4.90	5.30	0.00	1.00
	0.070	0.00	9.20	10.60	2.20	2.00
	0.080	1.00	9.20	11.80	2.20	3.00
	0.100	4.00	4.30	12.10	2.20	2.00
	0.120	4.00	4.30	12.10	2.20	2.00

Personnel Characteristics

AFQT

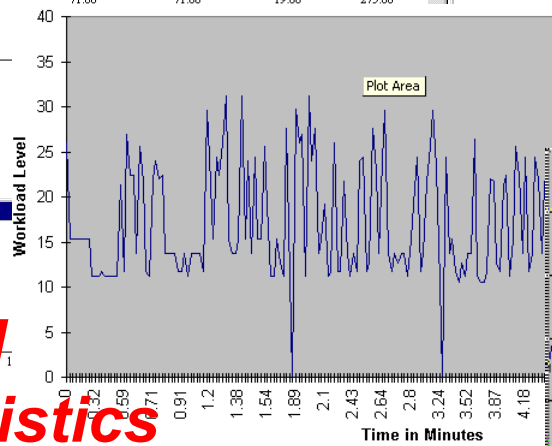
MOS:		I	II	IIIA	IIIB	IV	Total
67R	E1 - E3	10.00	84.00	81.00	44.00	6.00	225.00
	E4	16.00	190.00	148.00	97.00	26.00	477.00
	E5	4.00	110.00	71.00	71.00	19.00	275.00
	E6	5.00	97.00				
	E7	6.00	62.00				
	E8 - E9	0.00	0.00				
	Total	41.00	543.00				

MOS:		I	II
68B	E1 - E3	35.00	135.00
	E4	10.00	171.00
	E5	5.00	73.00
	E6	1.00	30.00
	E7		
	E8 - E9		
	Total		

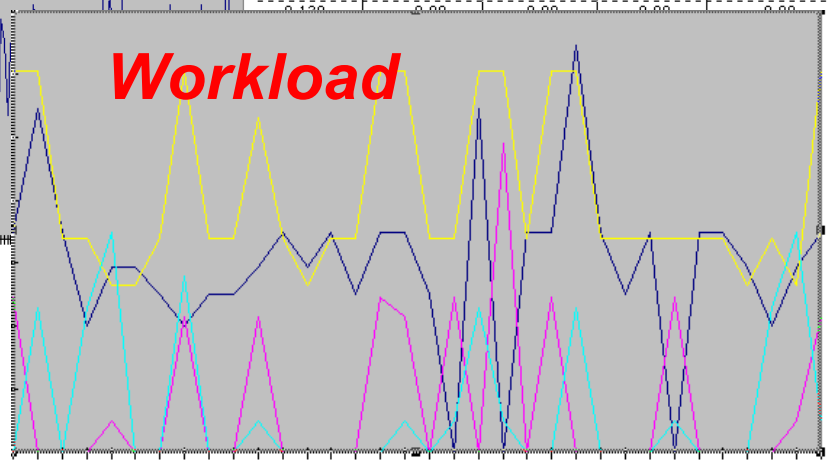
1 of 3

Reading Grade Level

MOS:							
67R	E1 - E3						
	E4						
	E5						
	E6						
	E7						
	E8 - E9						
	Total						
68B	E1 - E3						
	E4						
	E5						
	E6	0.64	16.64	16.42	40.71	1.59	76.00



Workload



Define Mission

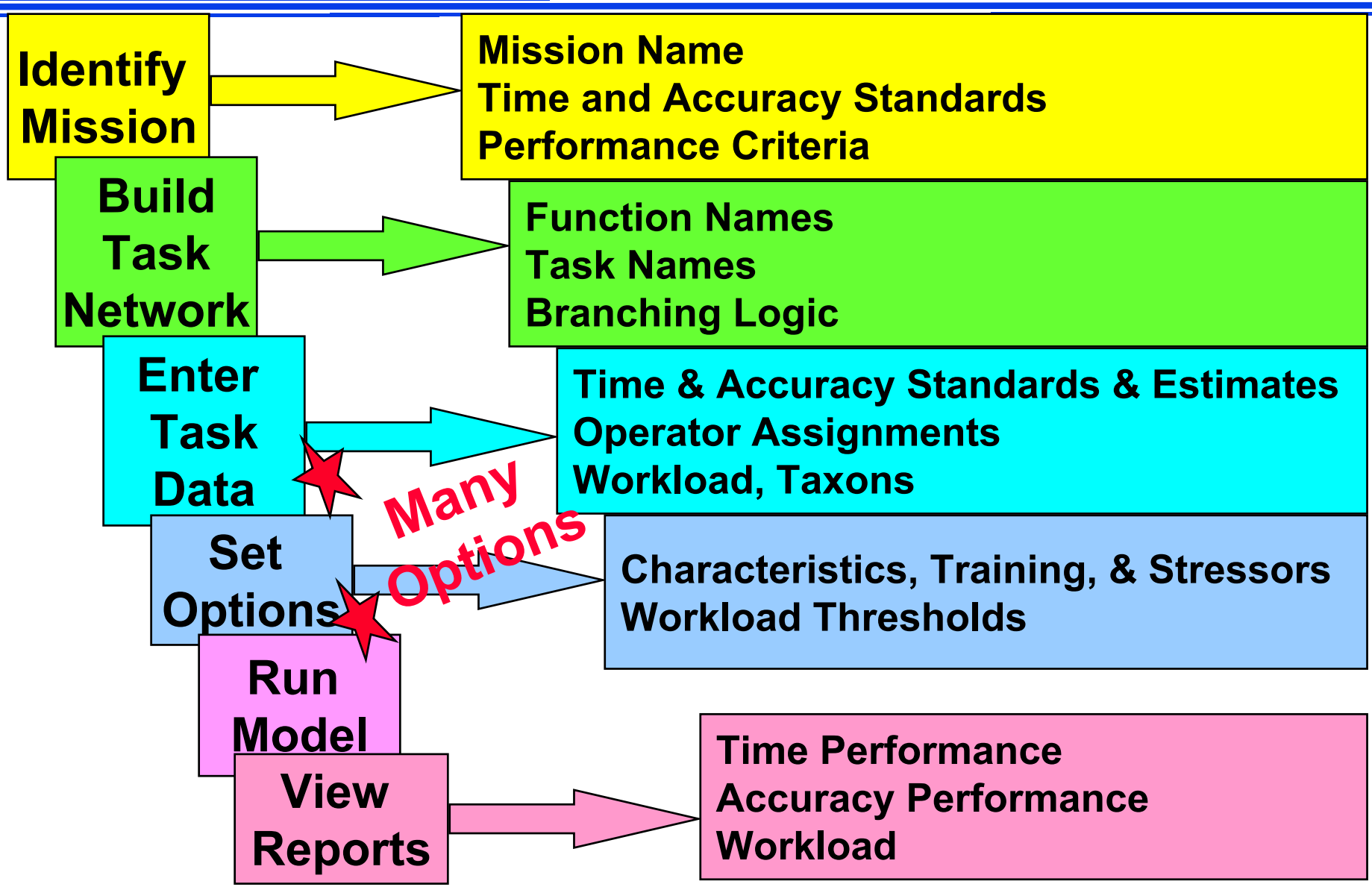
Define Mission Answers...

- How long will it take to perform my tasks?
- How much workload will be created?
- What is the probability of success?
- How should tasks be allocated across crewmembers and to automation?

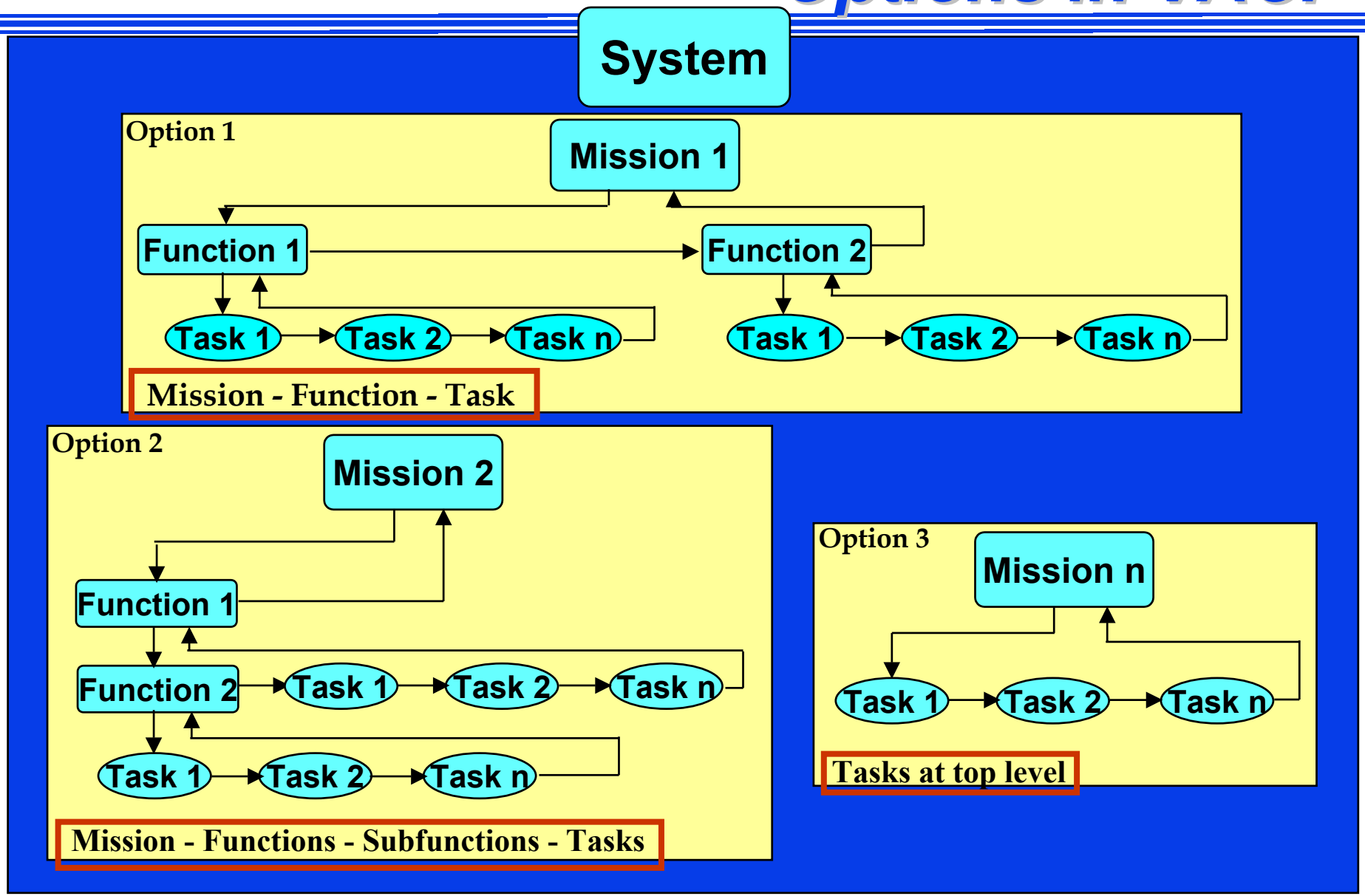
Define Mission Inputs

- Mission level
  - time standard
  - time criterion
  - accuracy criterion
  - mission criterion
- Function level
  - time standard
  - time criterion
- Branching logic
  - serial
  - multiple
  - repeating
  - probabilistic
- Task level
  - time standard
  - accuracy standard
  - criterion
  - time estimate
  - accuracy estimate
  - consequences of failure
  - workload
  - taxons
  - crew assignments

Define Mission Process



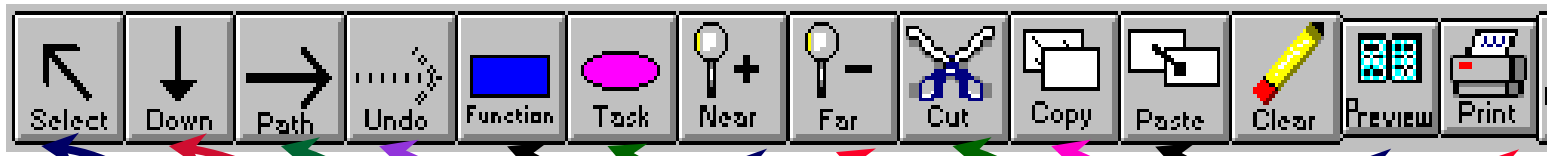
Task Network Hierarchy Options in VACP



Define Mission

- Micro Saint-based modeling tool
- Designed specifically for human operators of systems
- Evaluate system performance time and/or accuracy
- Has workload computations built-in
  - VACP or Wickens' MRT (Multiple Resource Theory)
- Has data collection built-in

Task Network Toolbar



selects a node

displays next level down

draws a path

erases a path

places a function node

places a task node

zooms in

zooms out

cuts a node (can paste)

copies a node

pastes a node

clears a node (can't paste)

shows page layout

prints the diagram

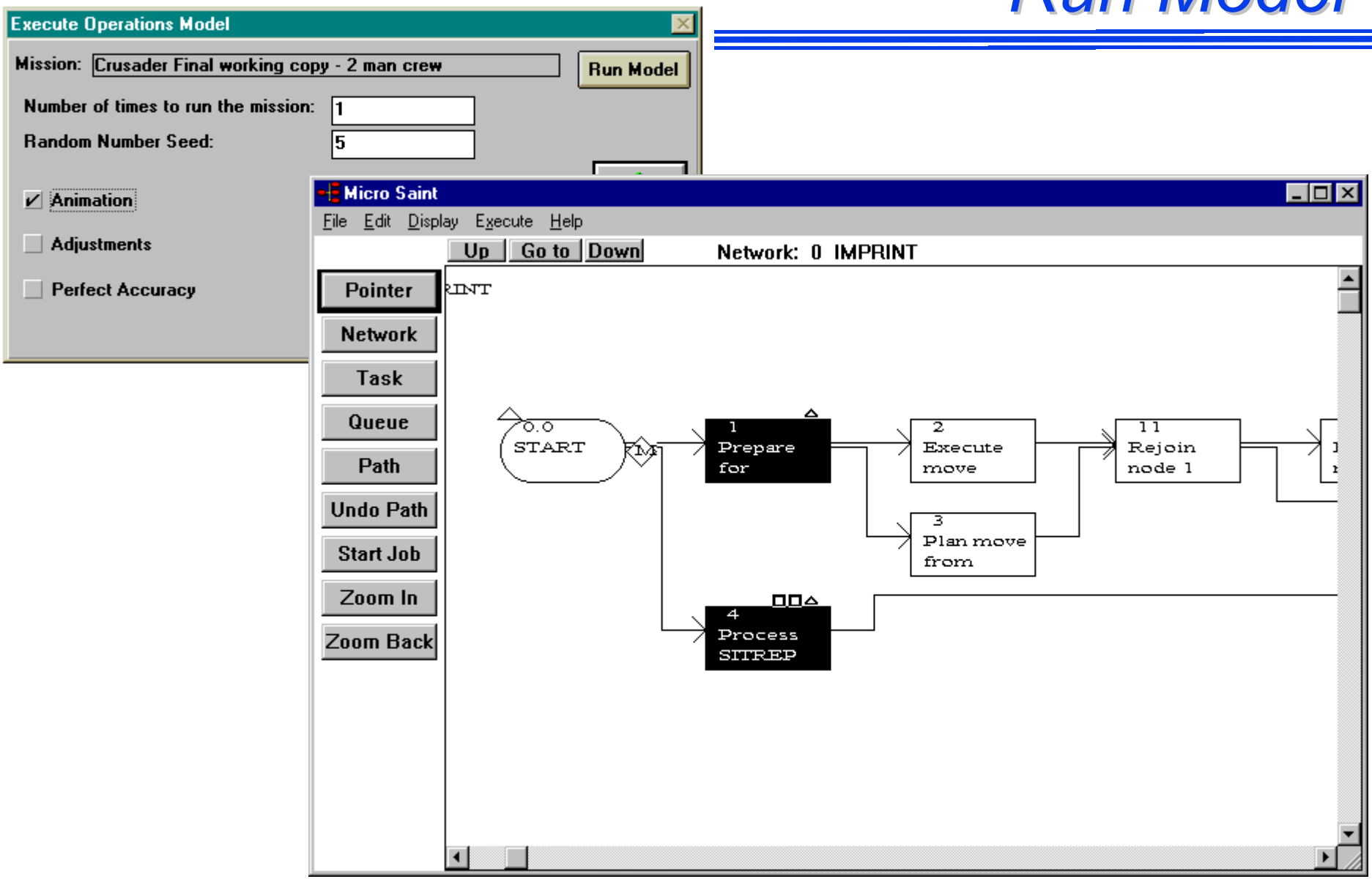
Enter Task Data

- Time
  - Standard
  - Mean & Standard Deviation
  - Micromodels
- Accuracy
  - Standard
  - Probability of Success
  - Mean & Standard Deviation
  - Consequences of Failure
- Operator assignments
- Workload
- Taxons

Assign Operators to Tasks

- Primary
  - Performs task regardless of current workload
- Secondary (Optional)
  - Has requisite skills and training
  - Used to recommend task reallocations

Run Model


Execute Operations Model
Mission: Crusader Final working copy - 2 man crew
Run Model
Number of times to run the mission: 1
Random Number Seed: 5
Animation
Adjustments
Perfect Accuracy
Micro Saint
File Edit Display Execute Help
Up Go to Down
Network: 0 IMPRINT
Pointer
Network
Task
Queue
Path
Undo Path
Start Job
Zoom In
Zoom Back
0.0 START
1 Prepare for
2 Execute move
11 Rejoin node 1
3 Plan move from
4 Process SITREP

Outputs of Define Mission

- Mission Performance
  - Predicted time & success rate
- Function Performance
  - Predicted time
- Task Performance
  - Predicted time & accuracy
- (And others you will see later)

Practical Exercise

VACP Workload Method

- Describes effort needed to perform task
- Helps identify peaks throughout the mission
- AKA “McCracken-Aldrich”
- Four independent channels
- Option to combine into “Overall” channel
- Does not dynamically impact performance
- “Adjust” feature helps evaluate high workload & reallocation of tasks to secondary operator

Mental Workload

Mission Tasks → **Which Brain Resources Involved?** → **Degree of Resource Use?**

1. monitor alarms
2. decide response action
3. pull trigger

.
.
.

n. task n

- Visual
- Cognitive
- Auditory
- Psychomotor

Visual

Auditory

Psychomotor

Cognitive

0.0	- No Cognitive Activity
1.0	- Automatic (simple association)
1.2	- Alternative Selection
3.7	- Sign/Signal Recognition
4.6	- Evaluation/Judgment (consider single aspect)
5.3	- Encoding/Decoding, Recall
6.8	- Evaluation/Judgment (consider several aspects)
7.0	- Estimation, Calculation, Conversion

Assign Workload

Visual

0.00 No Visual Activity
1.00 Visually Register/Detect (detect image)
3.70 Visually Discriminate (detect visual differences)
4.00 Visually Inspect/Check (static inspection)
5.00 Visually Locate/Align (selective orientation)
5.40 Visually Track/Follow (maintain orientation)
5.90 Visually Read (symbol)
7.00 Visually Scan/Search/Monitor(continuous)

Auditory

0.00 No Auditory Activity
1.00 Detect/Register Sound
2.00 Orient to Sound (general orientation)
4.20 Orient to Sound (selective orientation)
4.30 Verify Auditory Feedback
4.90 Interpret Semantic Content (speech)
6.60 Discriminate Sound Characteristics
7.00 Interpret Sound Patterns (pulse rate, etc.)

Assign Workload

Cognitive

0.00 No Cognitive Activity
1.00 Automatic (simple association)
1.20 Alternative Selection
3.70 Sign/Signal Recognition
4.60 Evaluation/Judgment (consider single aspect)
5.30 Encoding/Decoding, Recall
6.80 Evaluation/Judgment (consider several aspects)
7.00 Estimation, Calculation, Conversion

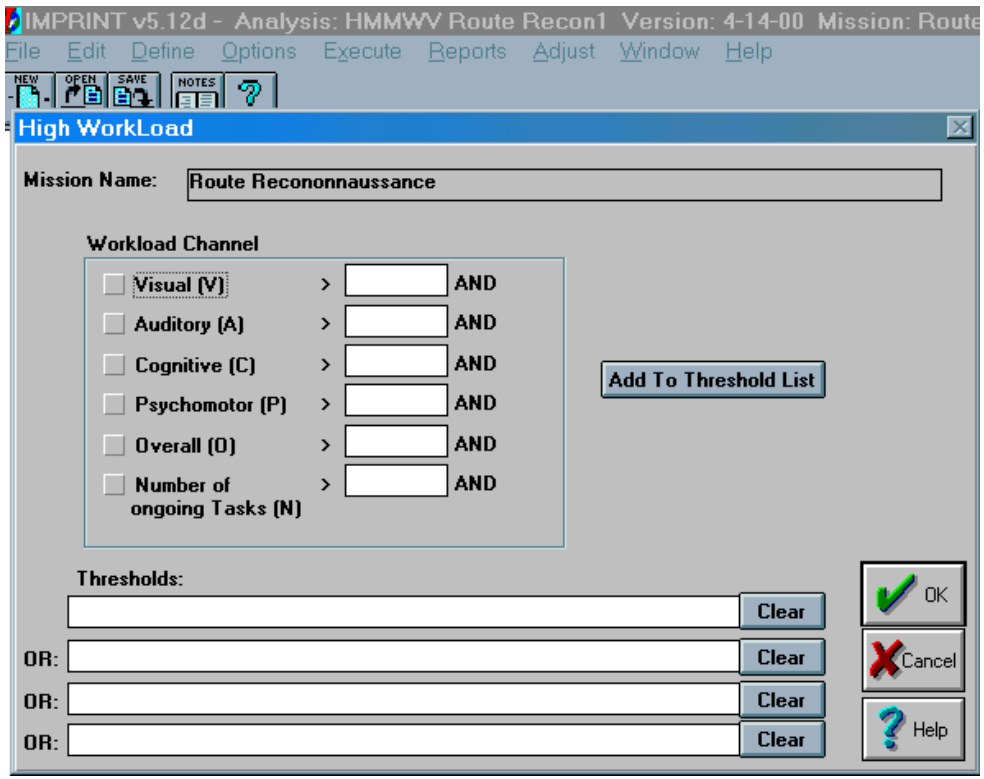
Psychomotor

0.00 No Psychomotor Activity
1.00 Speech
2.20 Discrete Actuation (button, toggle, trigger)
2.60 Continuous Adjustive (flight or sensor control)
4.60 Manipulative
5.80 Discrete Adjustive (rotary, thumbwheel, lever)
6.50 Symbolic Production (writing)
7.00 Serial Discrete Manipulation (keyboard entries)

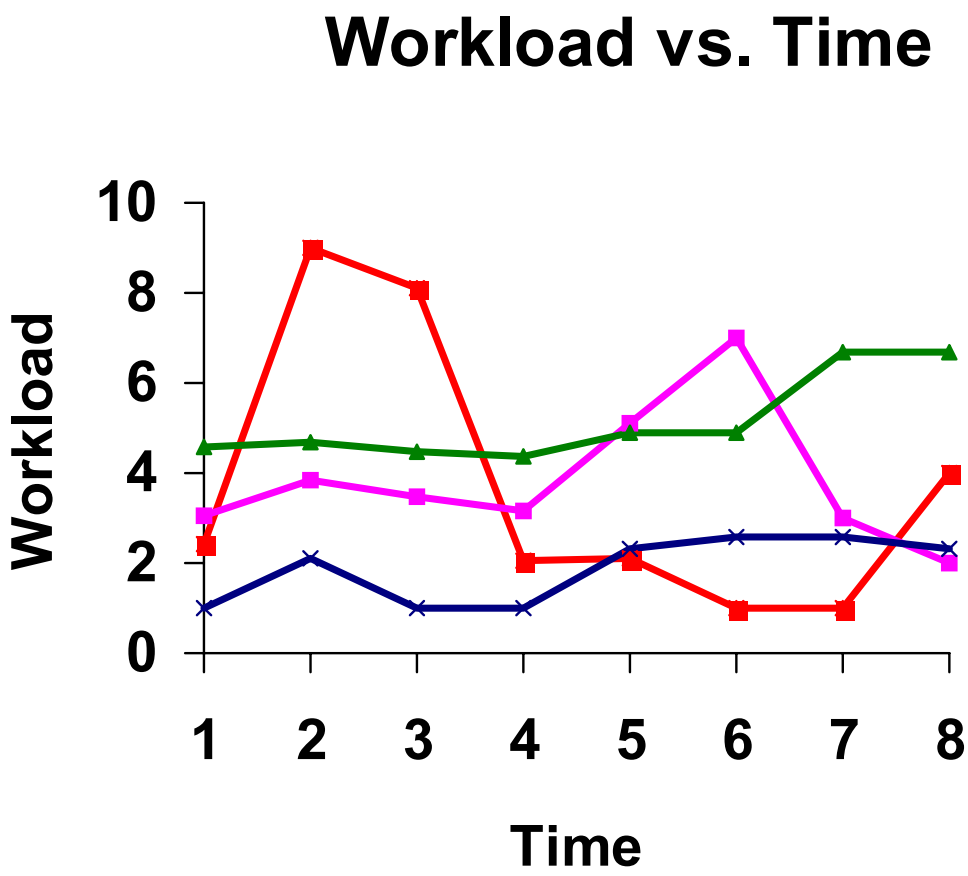
"High Workload" and Reallocation

- Under "Options," define up to 5 high workload thresholds
- When model runs, points where one or more thresholds are exceeded will be reported
- Under "Adjust," workload overload points can be reviewed, and assigned to a secondary operator if desired
- Then re-run model to re-check workload

(Be sure to save your original model before reallocating)
(And remember, workload does not dynamically affect performance here)



Analyze Results

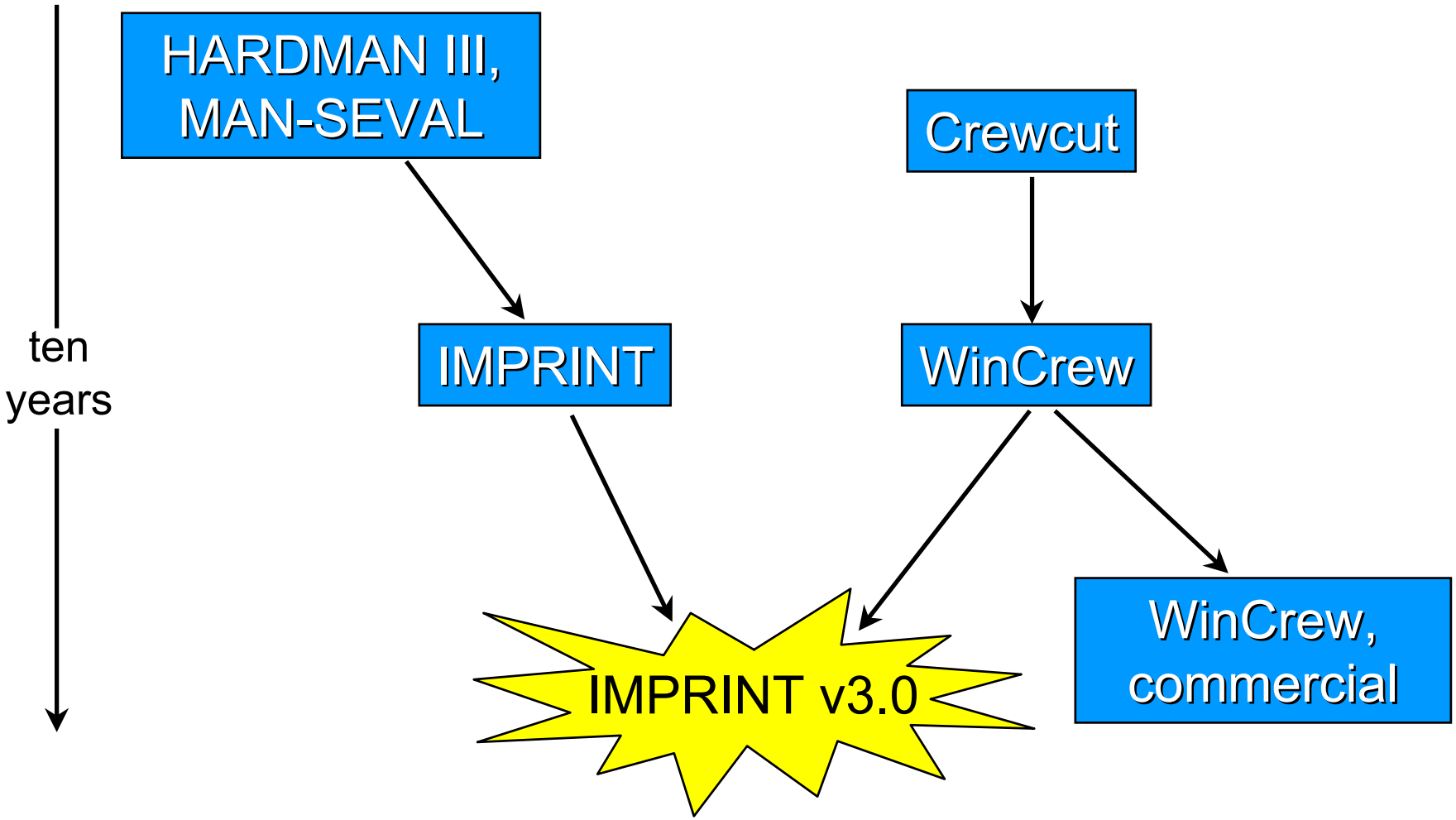


- Graphical report
- And workload by
  - channel
  - operator
  - & “overload”

Practical Exercise

Define Mission
Advanced Workload

ARL HRED Workload Modeling Tools



IMPRINT Workload Approaches

- VACP
  - Identify peaks thru-out mission
  - AKA “McCracken-Aldrich”
  - Four independent channels
  - Option to combine into “Overall” channel
  - Does not dynamically impact performance
- Advanced
  - Create > 4 resources
  - Link to controls and displays
  - Considers inter-channel conflict
  - Dynamically affects system performance
    - » Task flow, allocation, performance

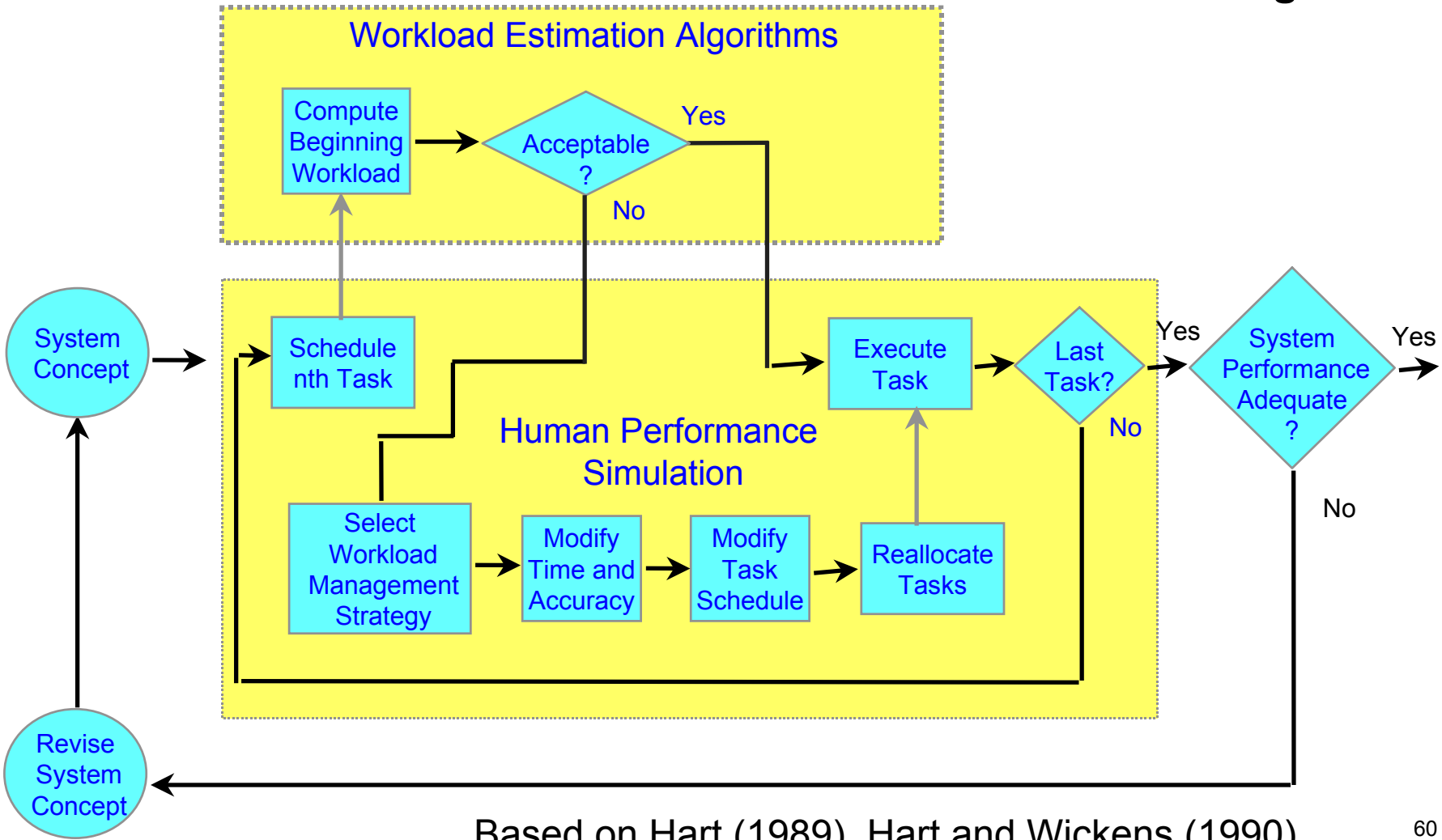
When to Use Advanced?

- Use VACP when…
  - Early in process
  - Identifying peaks is enough
  - Controls and interfaces are TBD
  - Need results quickly
- Use Advanced when…
  - Want to examine tasks very closely
  - Care about workload management
  - Want to consider conflict
  - Workspace design has identifiable alternatives
  - Have time to spend on detailed assessment

By the way, you can use your VACP network model for Advanced - & vice versa - with just a few constraints...

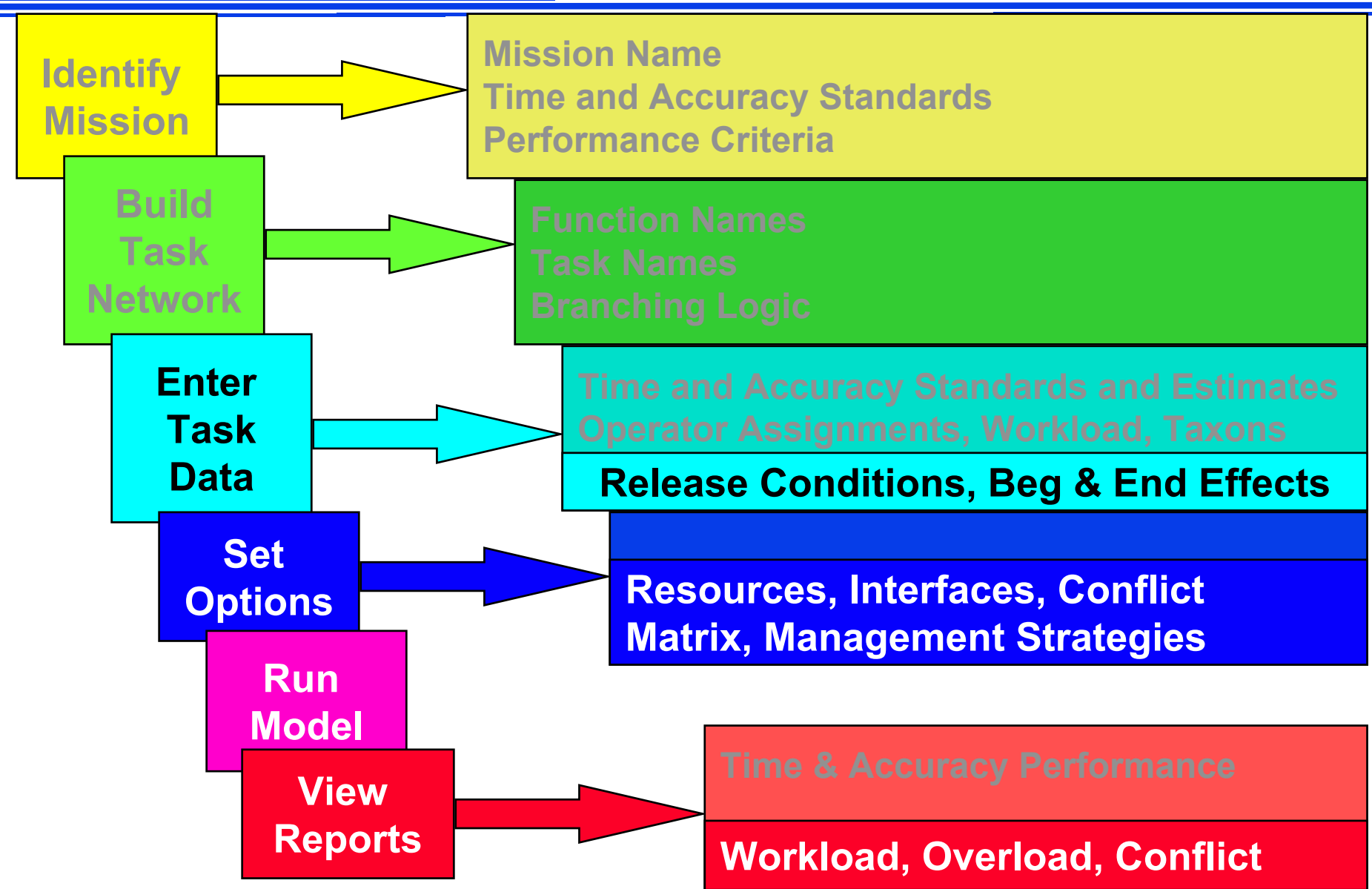
Advanced Workload Coping Behaviors

Interaction of Human Performance and Workload Estimation Algorithms

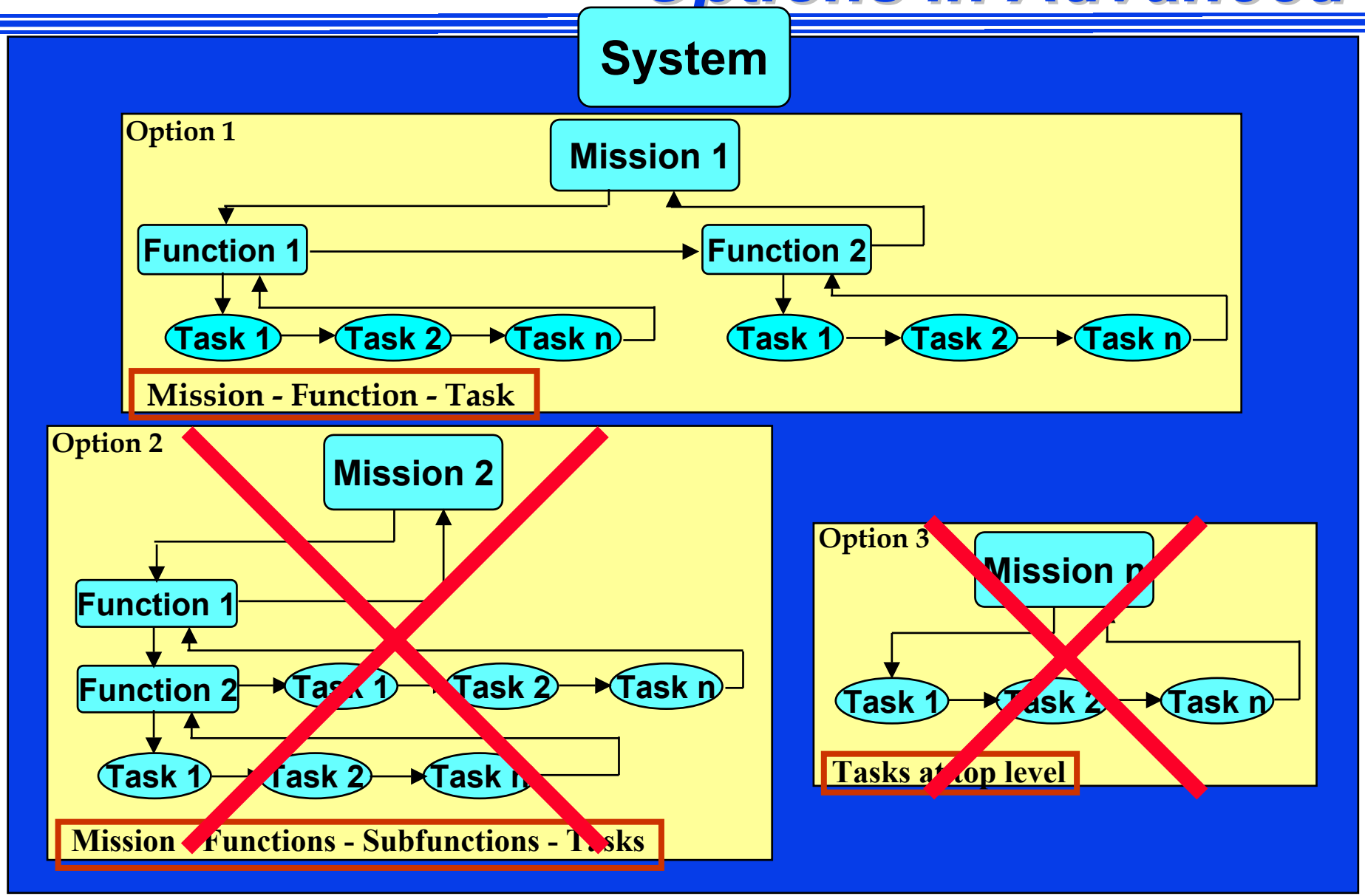


Based on Hart (1989), Hart and Wickens (1990)

Define Mission Process - Advanced



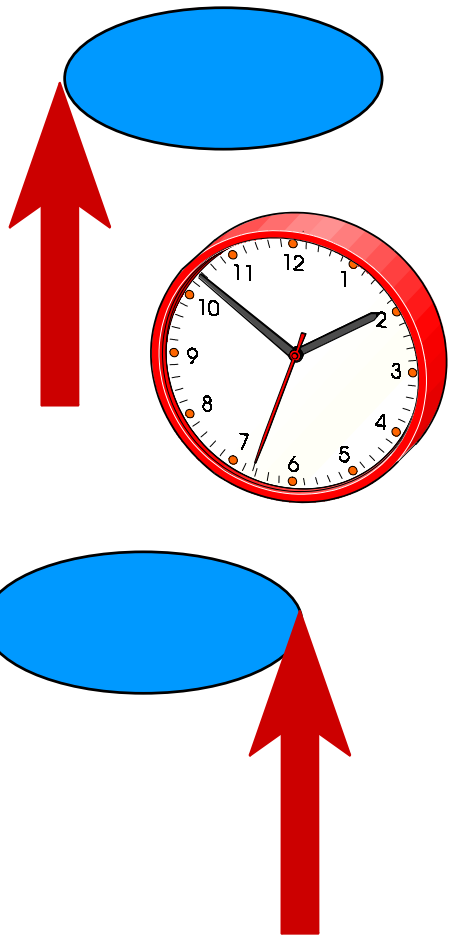
Task Network Hierarchy Options in Advanced



External Events

- Expressions that are inserted into model execution at selected clock times
- Can be used to cause task execution
- Used commonly to
  - Establish initial conditions of the system
  - Insert system changes (e.g., arrival rates)

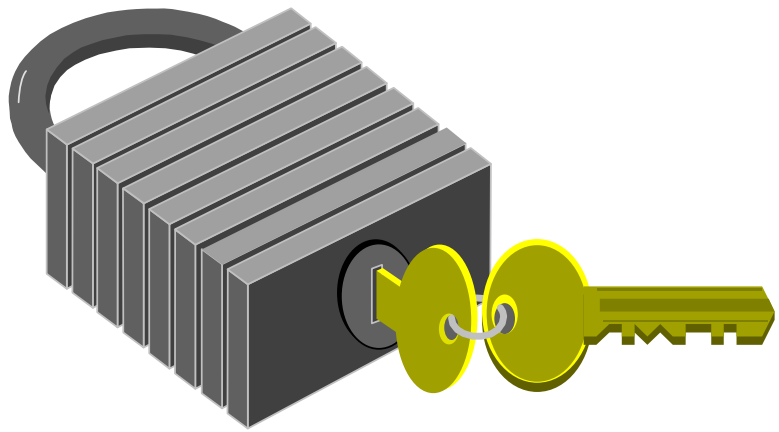
Task Effects



- Beginning effects
  - What happens to variable values as a result of a task beginning to execute
    - e.g., resources are used, counters are incremented
- Ending effects
  - What happens to variable values as a result of a task completing execution
    - e.g., resources are free, counters are decremented

Release Conditions

- Allows task to execute
- Establishes rules for task execution
- Can include multiple conditions
- Typically involves logical expressions



Advanced Workload Details

- Expressions must be used to control rejoining paths
  - Placed in Release Conditions, Beginning Effects, and Ending Effects
  - Use variables
  - Have syntax rules

Advanced Workload Details

- Variables
- Mathematical and Logical Expressions
- Beginning Effects
- Ending Effects
- Release Conditions
- Data Collection

Reference Information

Variables

- Most variables are defined by the user to represent conditions or parameters
  - Examples
    - » Resource availability
    - » Entity status
- Variable values can affect model execution
- Variable values are data to be collected

Variable Types

- Real
- Integer
- Arrays
  - Integer or real
  - 1, 2, or 3 dimensions
  - Indexed by a variable during a simulation
  - Think of them as tables with as many columns as you need

Reference Information

Arrays of Variables

- Often, we will want to store the same type of parameter values many times
  - Most common example is parameters regarding entities that flow through the system such as
    - When did it arrive
    - What kind is it
- In this situation use arrays

System Variables

- tag
  - A magical variable that keeps track of the number of the entity being acted on by any event at any time
  - Once you assign a value, it gets carried through
  - Each entity needs to have a unique tag number
  - Used primarily for referencing arrays that define attributes of entities

System Variables

- clock
  - The current simulation time
  - Starts at zero
  - No expected resemblance to “real time”
- run
  - When you have multiple runs of the network, this tells you which run you’re in
  - Can be used to change conditions across runs

Expressions

- Expressions are used to initially set or change variable values in Micro Saint & WinCrew models
  - Examples
    - » To set and change resource availability
    - » To set and change entity states
- Two general types - mathematical and logical expressions

Reference Information

Mathematical Expressions

- Operators

( )	grouped operations
^	exponentiation
*	multiplication
/	division
%	remainder division
+	addition
-	subtraction

Reference Information

Advanced Expressions

- Logical operators

>	greater than
<	less than
>=	greater than or equal to
<=	less than or equal to
<>	not equal to
|	logical or
&	logical and
= =	equal to (e.g., if a== b then...)
: =	assignment

Reference Information

Advanced Expressions

- Logical statements

```
if
then
else
    if a>b then time:=5 else time :=7;
while ... do
    while i < 5 do type[i] := 1, i++;
```

Reference Information

Advanced Expressions

- Adjustment operators

+=	Increment by adding
- =	Increment by subtracting
/ =	Increment by dividing
* =	Increment by multiplying

Reference Information

Advanced Expressions

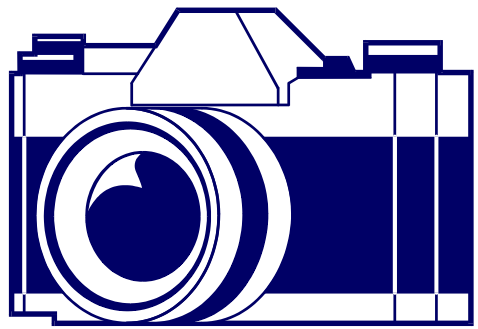
- Separators

;	end of expression e.g., a:=1;
,	separates assignments within expressions e.g., if a<1 then b:=5 , c :=6 else b:=4 , c:=2;

Reference Information

Snapshots of Execution

- Used to collect data during a model run
- Each snapshot defines variables to be stored during execution
- Data collection can be triggered on
  - Task execution
  - Entities going into or departing from queues
  - Clock time
  - End of the run



Assign Operators to Tasks

- Characteristics
  - Automation, aptitude, experience, fatigue
- Primary (one only)
  - Performs task unless in overload
- Contingency (<=5)
  - Has requisite skills and training
  - Used to implement management strategies

Advanced Workload Management

- User-defined workload threshold values
- Management of tasks over threshold
  - A No effect
  - B New task doesn't begin
  - C New task performed in serial
  - D Drop current task
  - E Hand-off new task
  - F Hand-off old task

Advanced Workload Variables

- Used to create advanced workload strategies
- Used in if...then.. statements
  - P task priority value
  - H highest priority of ongoing tasks
  - T Total workload for op if new task added
  - S this operator's workload threshold

if P>H then F

"If new task's priority is greater than ongoing task's priority, then reallocate the ongoing task to a contingency operator"

Define Resources and Interfaces

Resources

- Default set
  - Visual
  - Auditory
  - Motor
  - Speech
  - Cognitive
- Add up to 5 more

Interfaces

- Controls and displays in your design
- Don't get carried away!

Be prudent!

Aggregate Workload

ADVANCED WORKLOAD CALCULATION:

$$W_T = W_{STD} + (W_{WCC} + W_{BCC})$$

Where:

W_T = Instantaneous Workload at Time T

W_{STD} = Workload attributable to the demands of all operator's tasks at time T (Single Task Demands)

W_{WCC} = Workload attributable to Within-Channel Conflicts (Within and between tasks)

W_{BCC} = Workload attributable to Between-Channel Conflicts (Between tasks only; within tasks may see improved performance "S-C-R")

* Adapted from W/Index North & Riley, 1988

Assign STD's

- Build RI pairs and assign to tasks
- Slight differences from VACP scales
- Modified by Chris Wickens
- Pop-up scales accessed by double-clicking the cell

Assign Conflicts

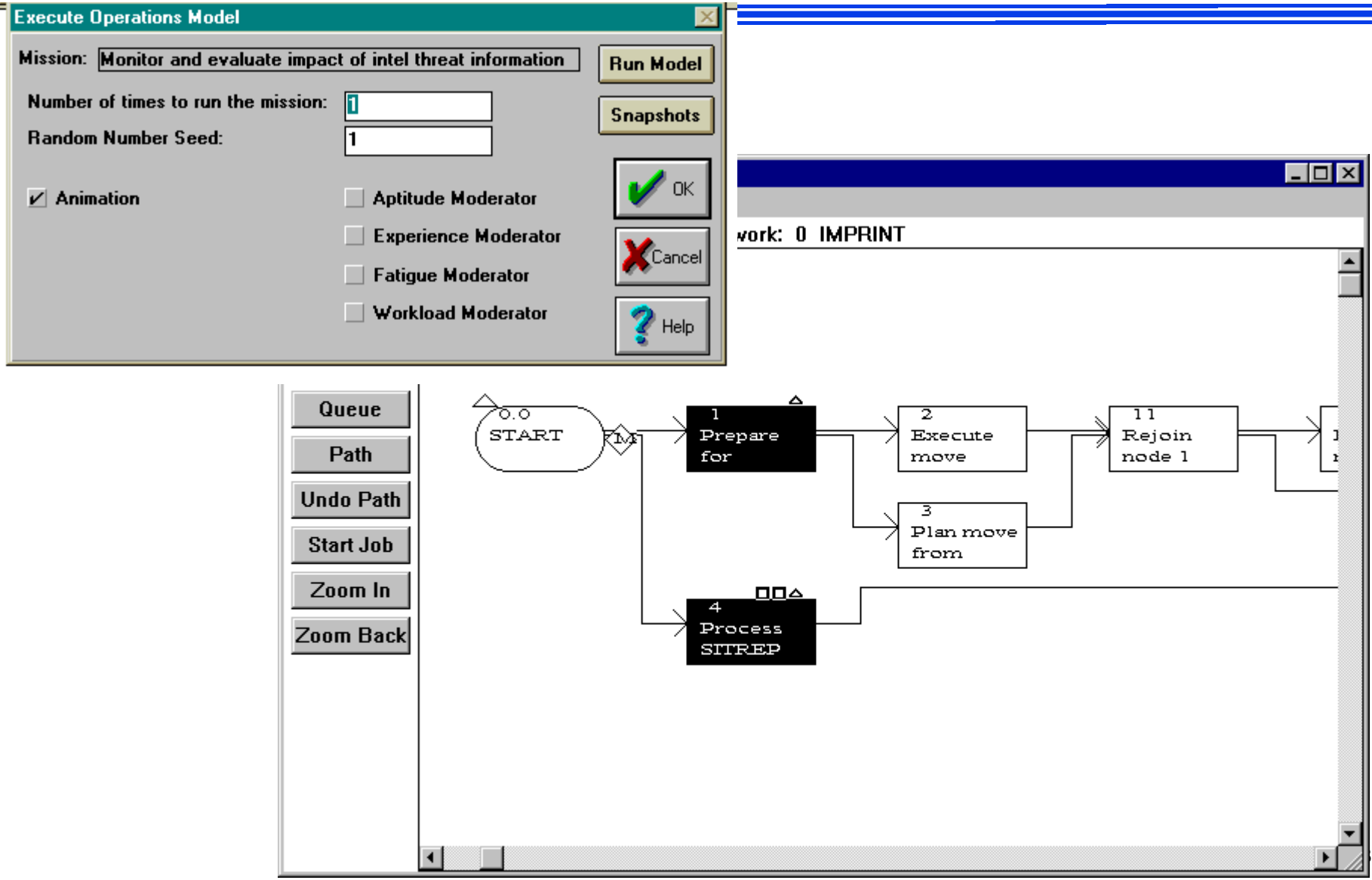
- BIG contributor to workload score
- Matrix of channels X channels, upper diagonal
- Cell values range from 0.00 -1.00
- Double click on row header provides “expert guidance” and default values

Advanced Workload Method

- Describes effort needed to perform task
- To help examine impact of workload during mission
- Results are combined across channels into one score
- Results consider inter- & intra-channel conflict
- Does dynamically impact performance

Time, Accuracy, Crew Allocation, Sequence

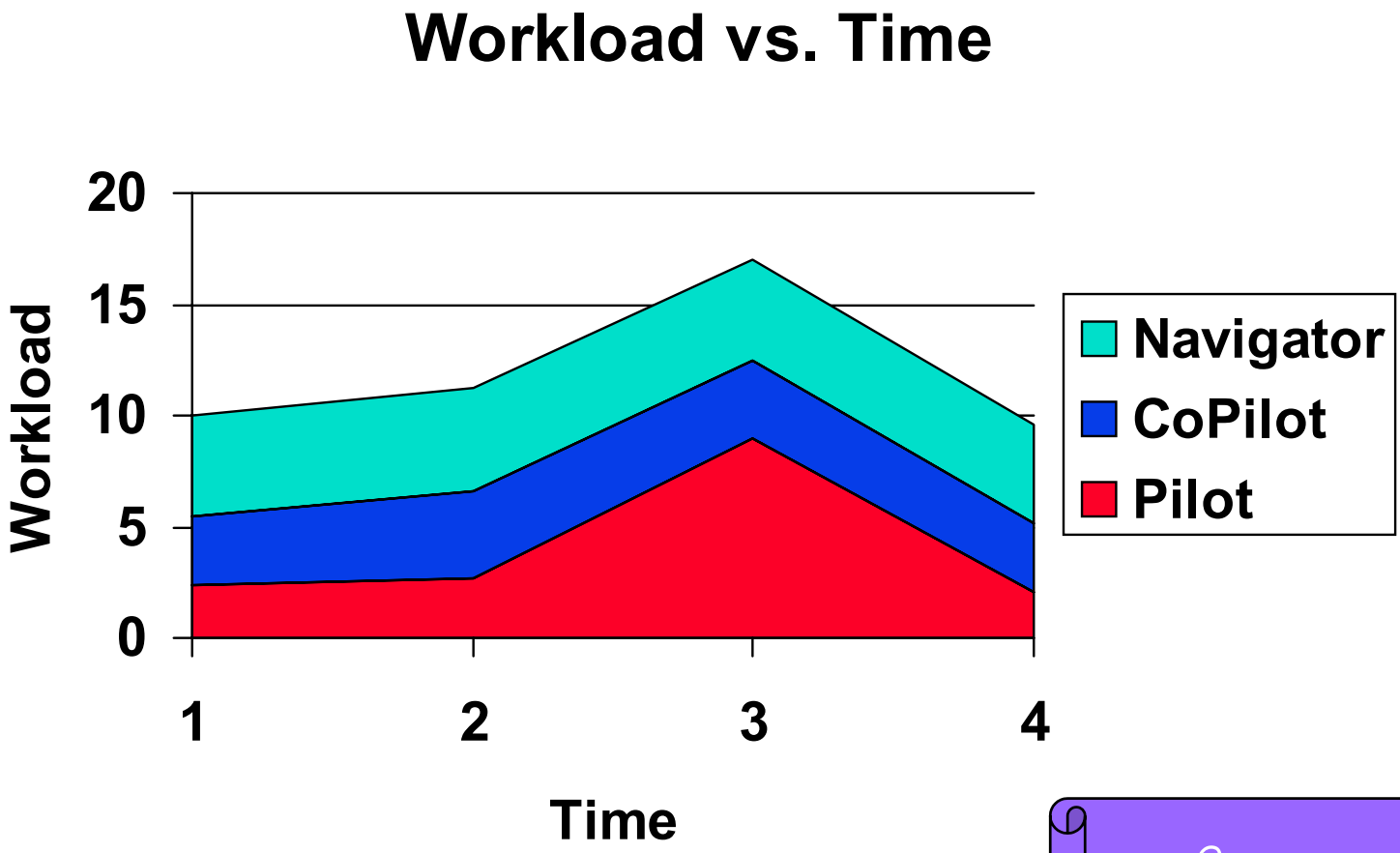
Run Advanced Model



Unique Outputs of Advanced Workload

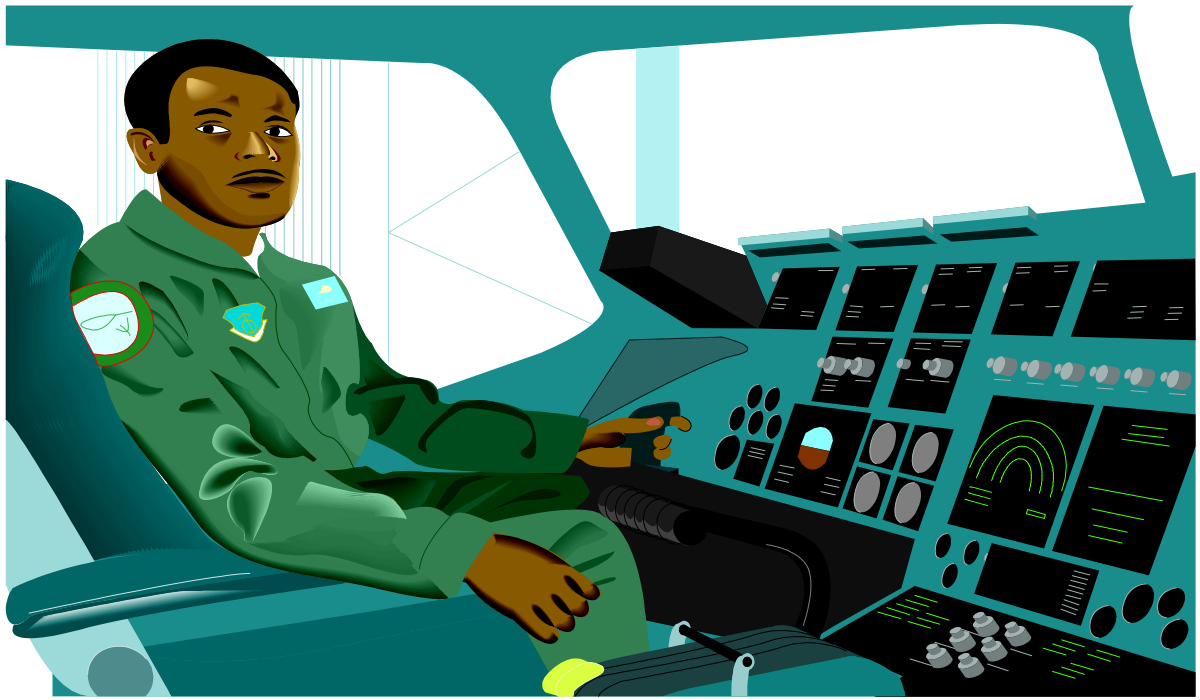
- Critical Path
- Operator Activity
- Operator Workload
- Overload
- Channel Conflict
- Task Timeline
- CrewStation Workload
- User Snapshot

Analyze Results



Practical Exercise

Define Soldiers



Define Soldiers Analyses

> *Stand Alone*

> Operators in
Define Mission

> Maintainers in
Define Equipment

> MOSs in
Define Force

Personnel

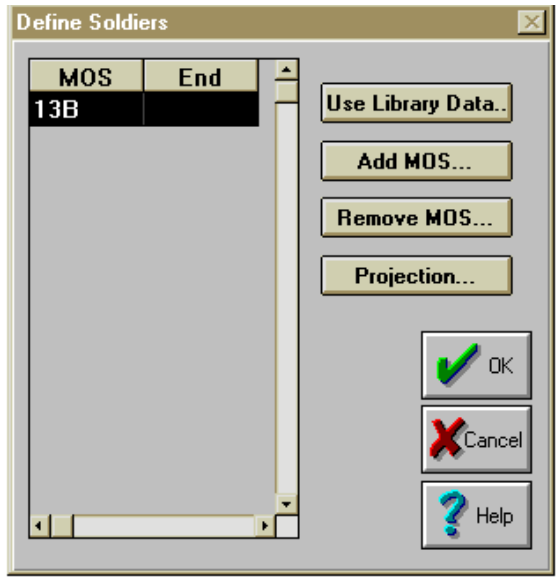
Characteristics

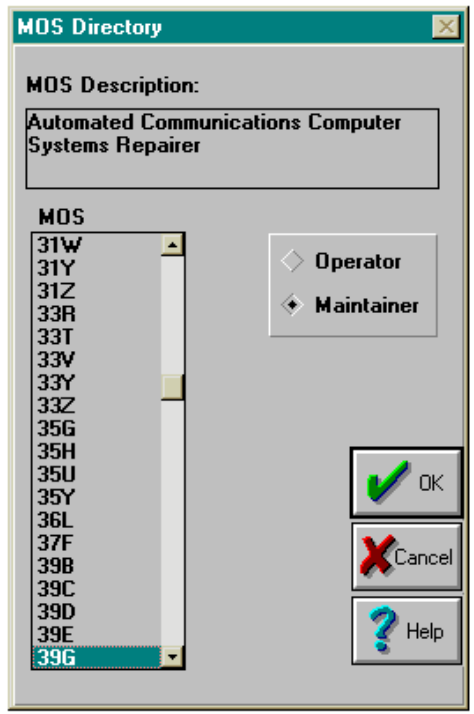
Define Soldiers

- Add or Delete MOSs
- Run Projection Model
  - Optional, but required to look at Personnel Reports
- Adjust Projection Model Parameters
  - Optional

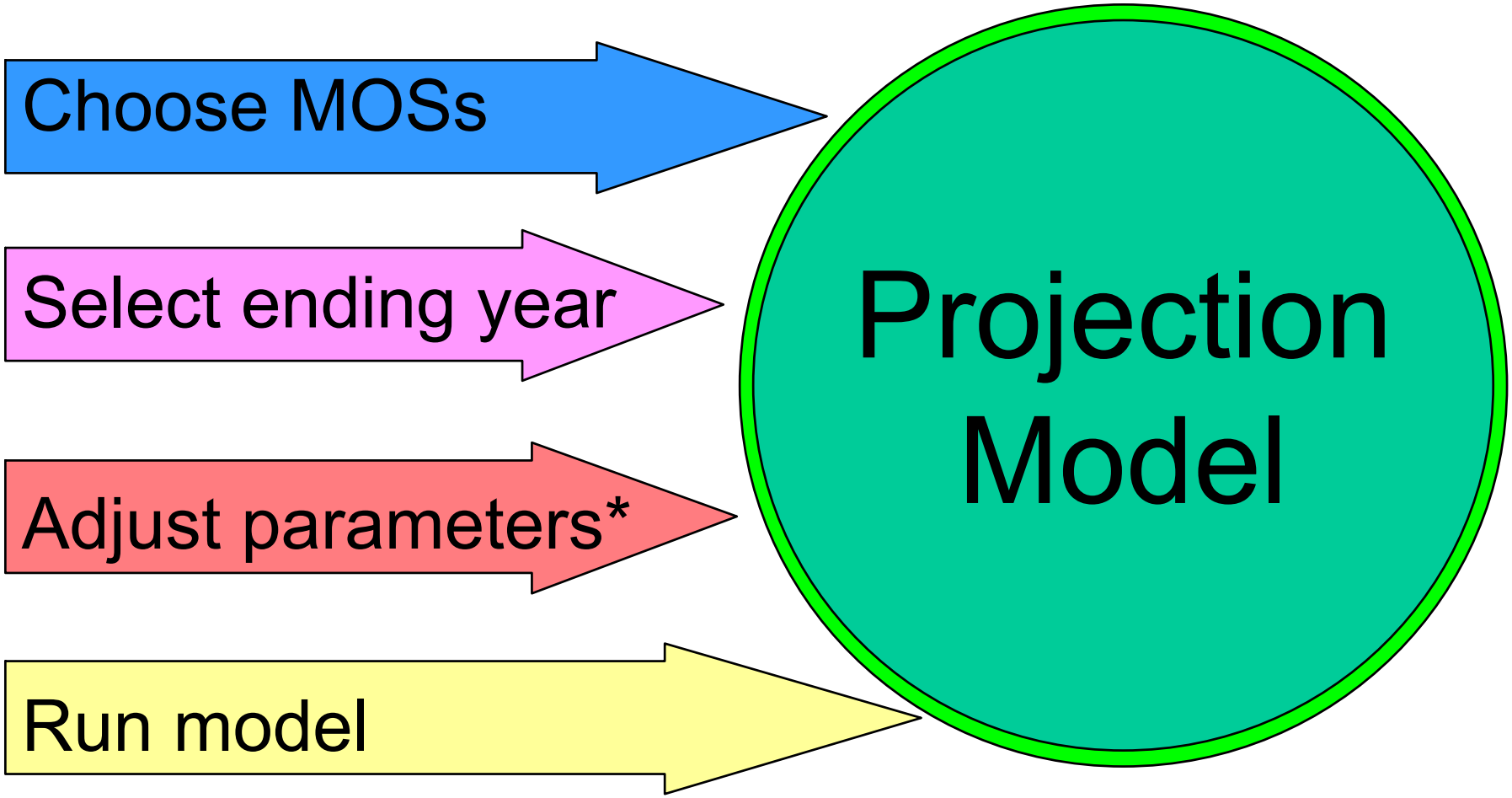
Add or Delete MOSs

- Operators and Maintainers
- "Dummy" MOS's (for Civilians or Contractors) & Officers
- Personnel Characteristics Data for MOSs



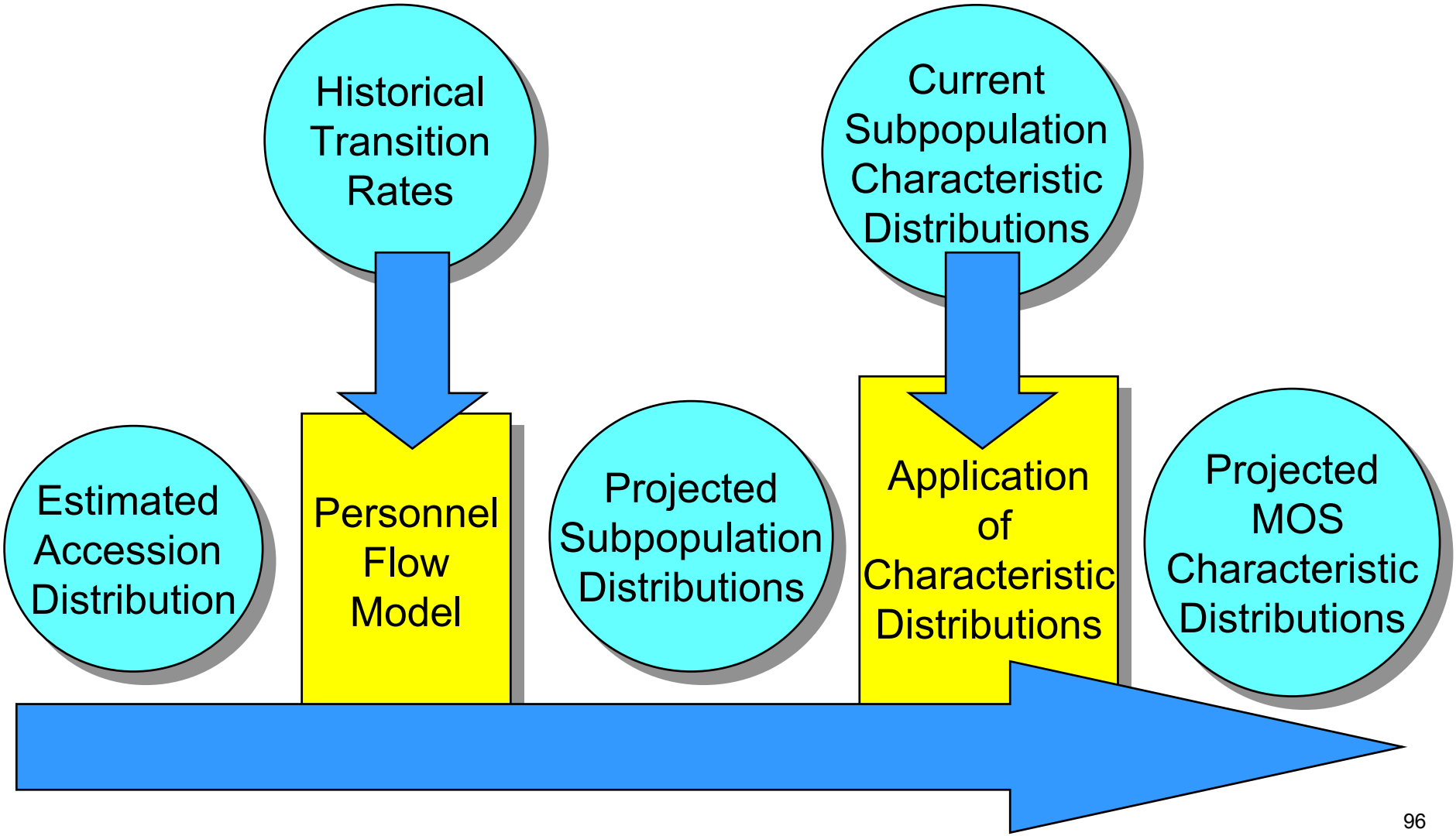


Run Projection Model



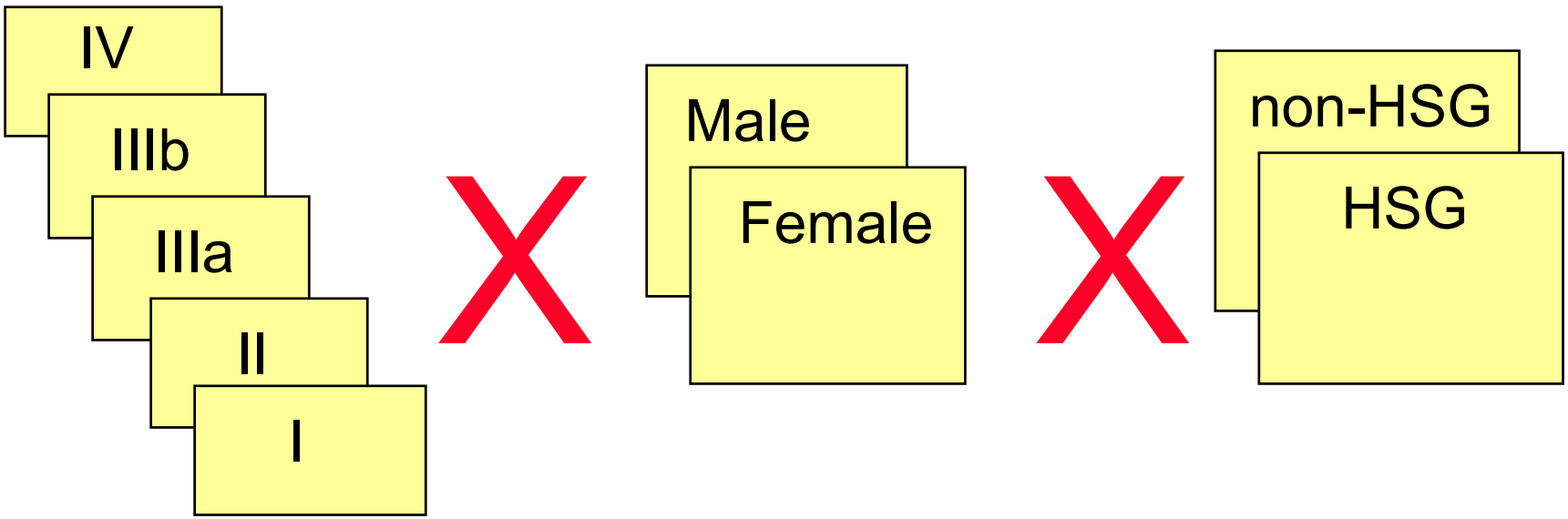
* optional step

Projection Model



Subpopulations

By MOS and Grade



Each subpopulation is flowed separately

Projection Model Data

- Historical accessions
- Promotion rates
- Separation rates
- Migration in & out rates
- Current inventory

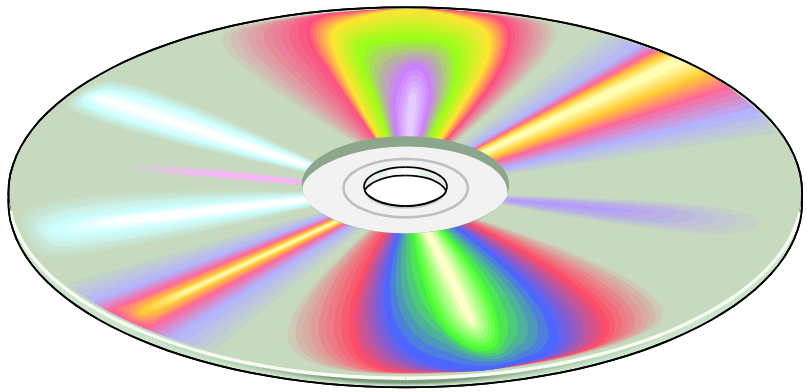
Adjust Endstrength

- Adjustments for “downsizing”
- “Cookie cutter” approach

Use Army Library Data

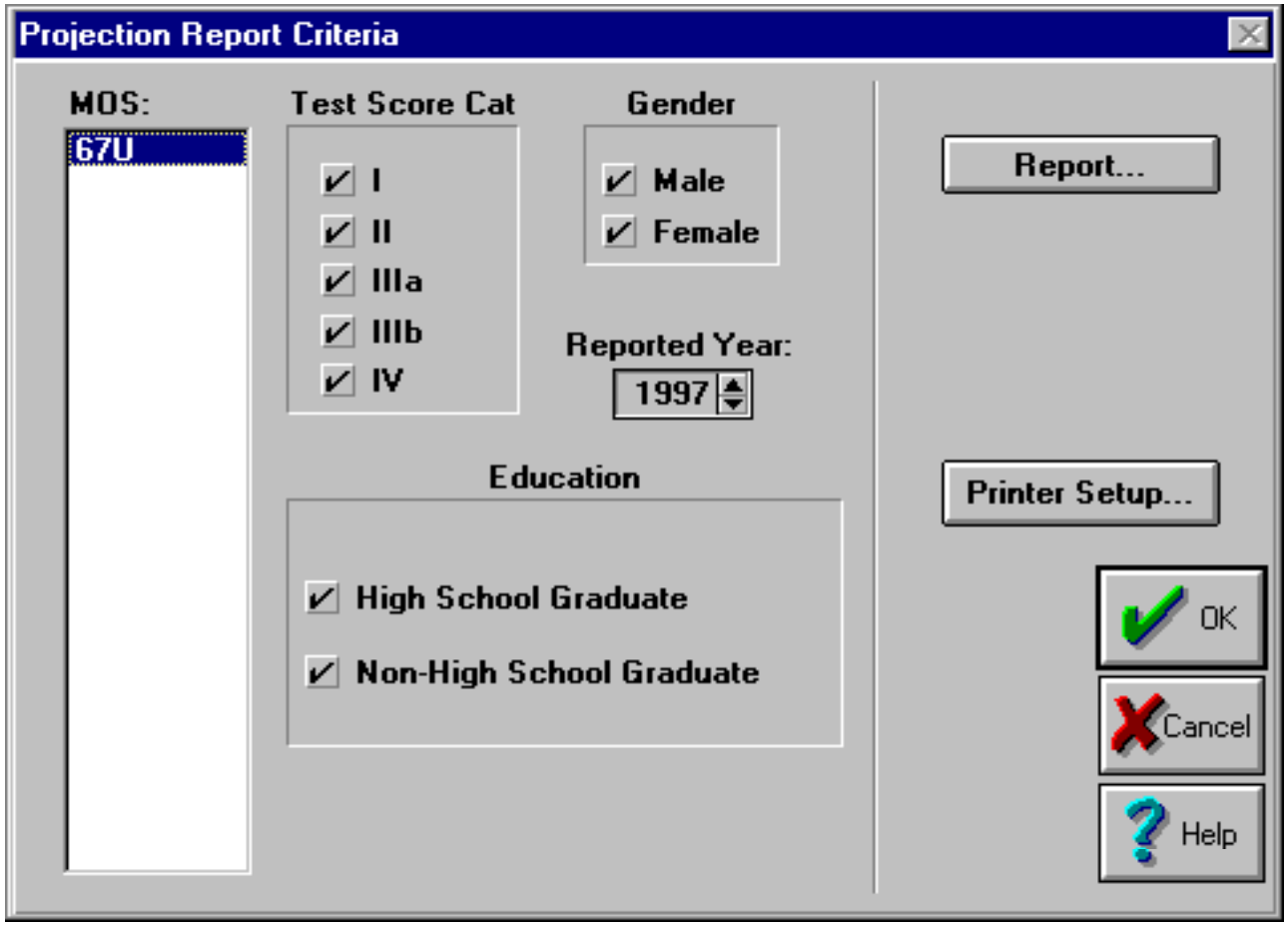
- MOS data for 22 historical systems
- Operators and maintainers
- Associated personnel characteristic data

MARC Maint. Database

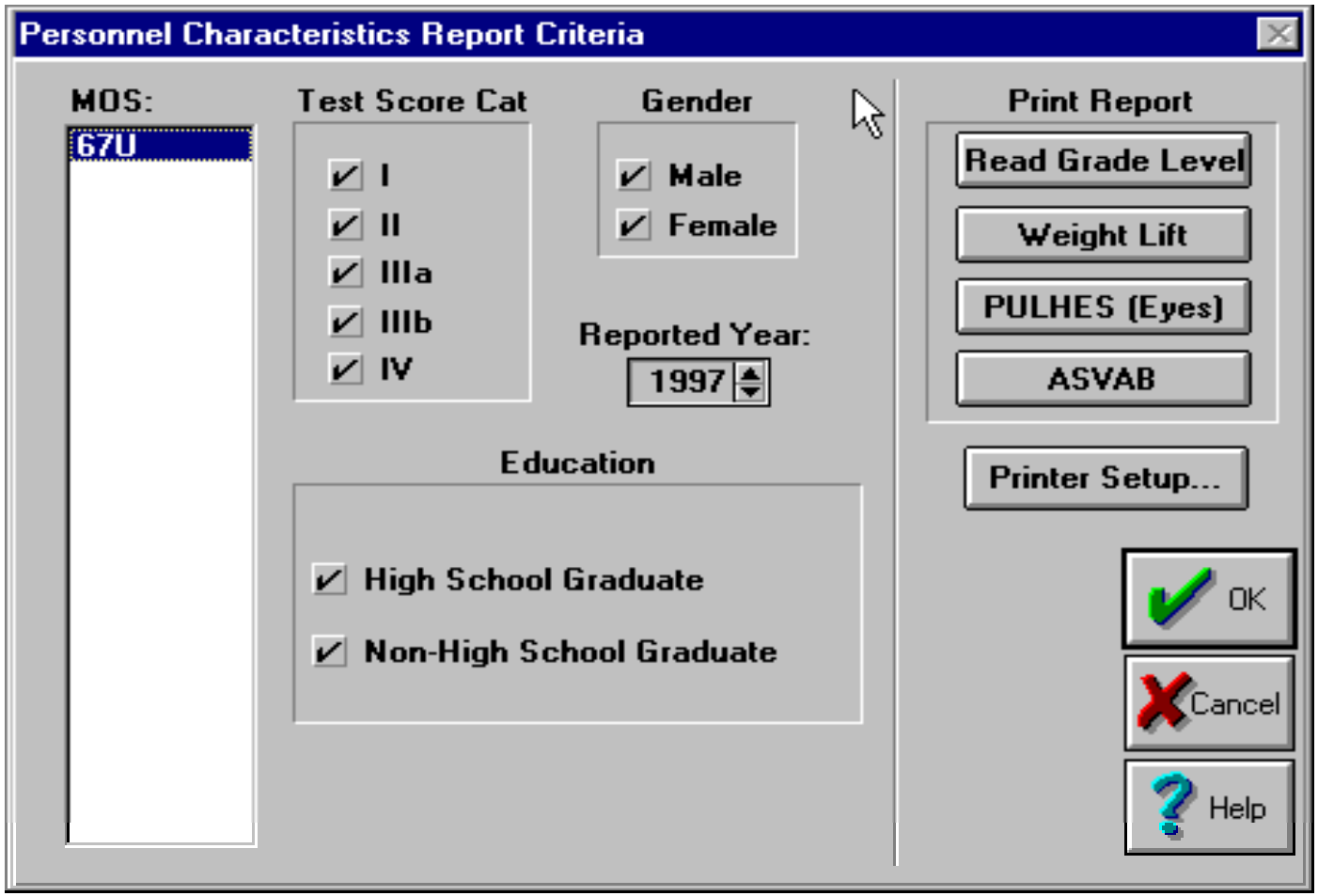


Enlisted Master File

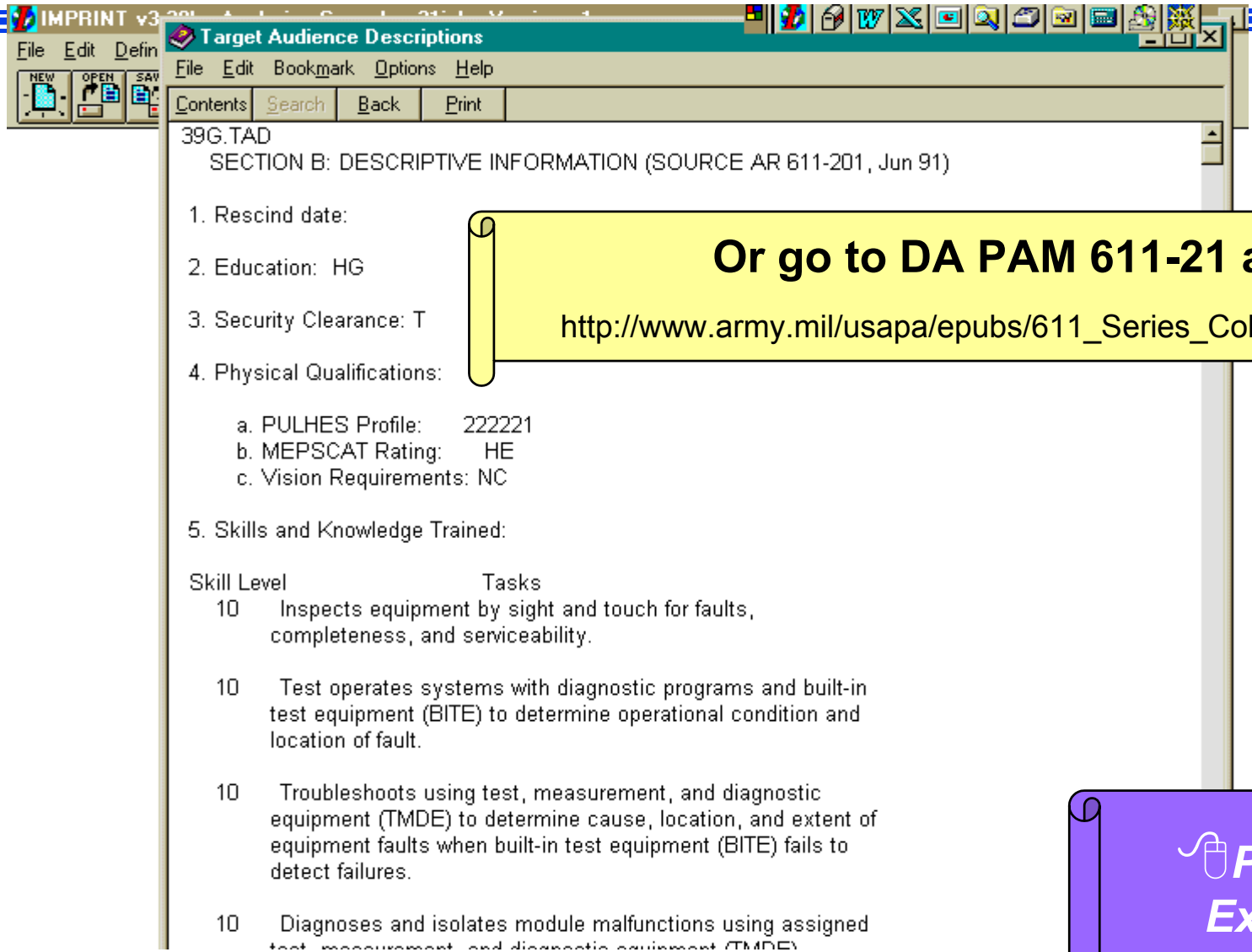
Define Soldiers Reports



Define Soldiers Reports (cont)



Target Audience Description Info



Or go to DA PAM 611-21 at:

http://www.army.mil/usapa/epubs/611_Series_Collection_1.html

Practical Exercise

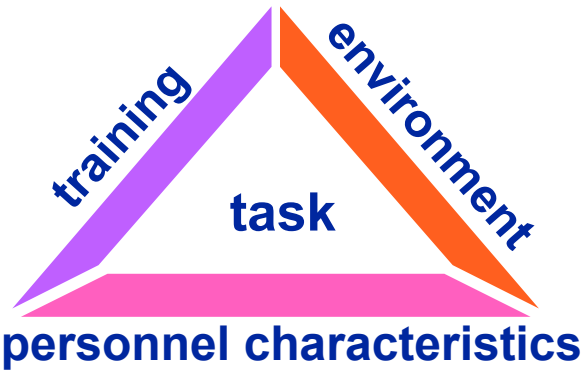
Stressors & Performance Shaping Functions

Modeling Human Performance

- Discrete event task networks

Define Mission

- Performance measures
  - Time
  - Accuracy



- Factors affecting human performance
  - Personnel characteristics
  - Sustainment training
  - Environmental stressors

Evaluate performance under different conditions

Applying PTS* Options

** Personnel, Training, Stressors*

- For VACP missions only
- Apply stressors by individual task
- Or for all tasks for an MOS or crew position
- Tasks must be described via "taxons"

Soldier Performance Shaping Functions

- Used Project A database - ARI
  - **1985 data**
  - **9,500 soldiers total**
  - **9 different military occupational specialties**
  - **full data set on 9-MOS sample = 5,000 soldiers**
  - **updated in 1997 with longitudinal data**

11B-Infantryman
13B-Cannon Crewman
19E-Tank Crewman
31C-Radio Teletype Op
63B-Veh & Gen. Mech Spc.
71L-Admin Spec
91A-Med Care Spec
88M-Motor Transport Operator
95B-Military Police)

- Derived algorithms describing relationship of MOS personnel characteristics and training frequency & recency with task performance by task type

- Provided "what if" options in IMPRINT

Sustainment Training

- Characterized by frequency & recency
- Users specify frequency & recency
  - Once a week or more
  - 
  - Less than twice a year
- Can be applied task-by-task or all tasks

IMPRINT Stressors

- ✔Mission-oriented protective posture gear
- ✔Heat & humidity
- ✔Cold & wind speed
- ✔Noise
- ✔Sleepless hours

When applied to tasks -

- » Less accurate task performance
- » Or increased task time
- » Or both

Not all tasks are affected in the same way or by the same stressor

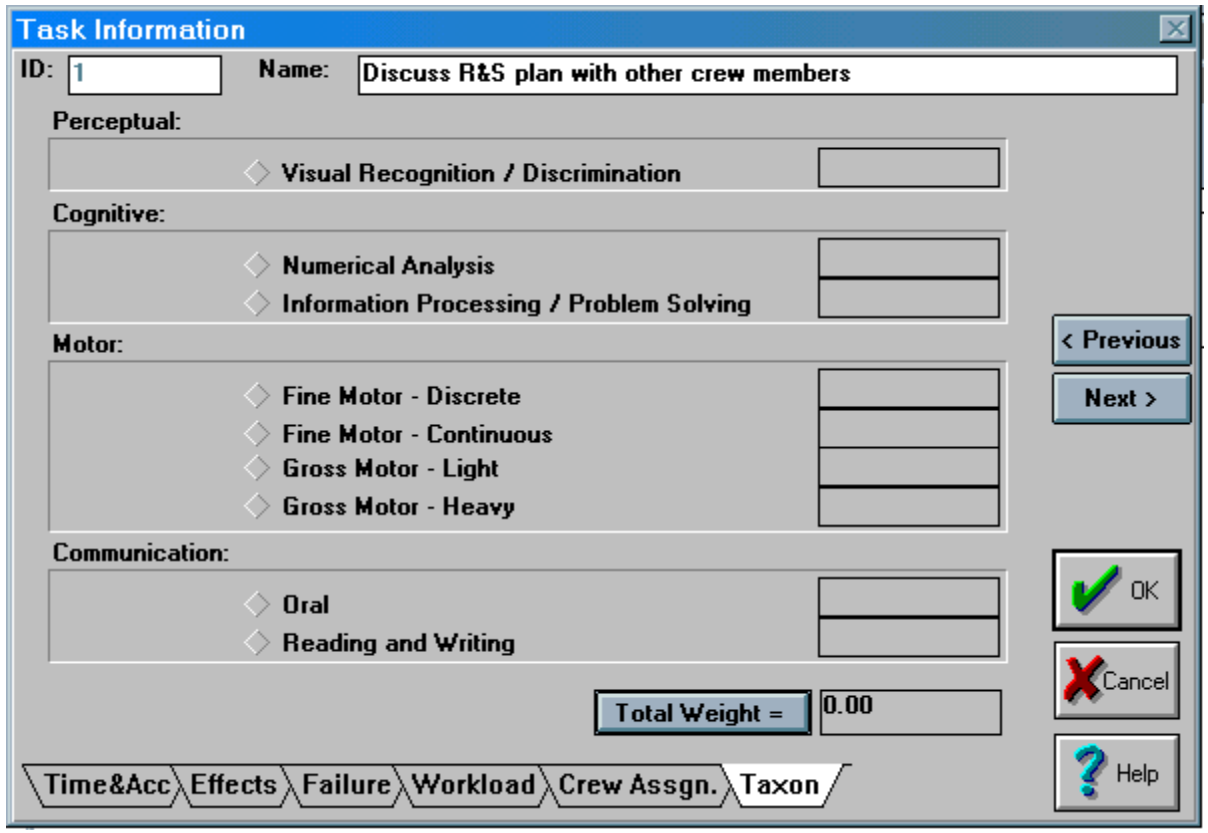
Assign Taxons

- Under “Define Mission” Task Data
- Describe composition of the task
- Use to calculate impact of personnel characteristics, stressors and training
- Nine categories
- Choose <=3 and assign weightings

Can automatically convert VACP workload ratings into taxon assignments

Taxons

- Visual Recognition/Discrimination
- Numerical Analysis
- Information Processing/Problem Solving
- Fine Motor Discrete
- Fine Motor Continuous
- Gross Motor Light
- Gross Motor Heavy
- Communication - Oral
- Communication - Read & Write



Impact of Stressors by Task Type

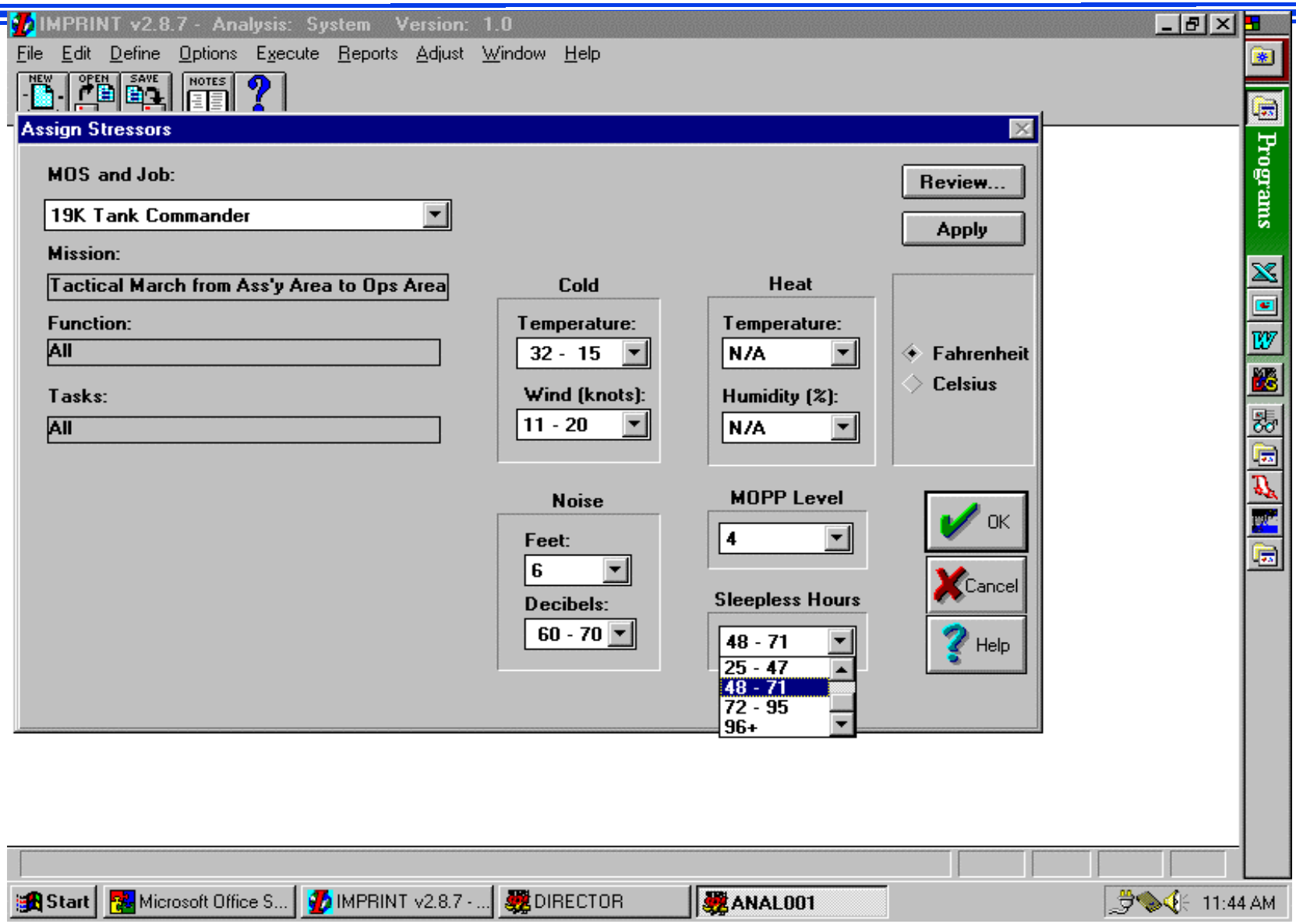
Taxon	MOPP	Heat	Cold	Noise	Sleepless Hours
Visual	T	A	T		
Numerical		A			TA
Cognitive		A			TA
Fine Motor Discrete	T	A	T		
Fine Motor Continuous					
Gross Motor Light	T		T		
Gross Motor Heavy					
Commo. (Read & Write)		A			
Commo. (Oral)	T	A		A	

T = affects task time, A = affects task accuracy, TA= affects both

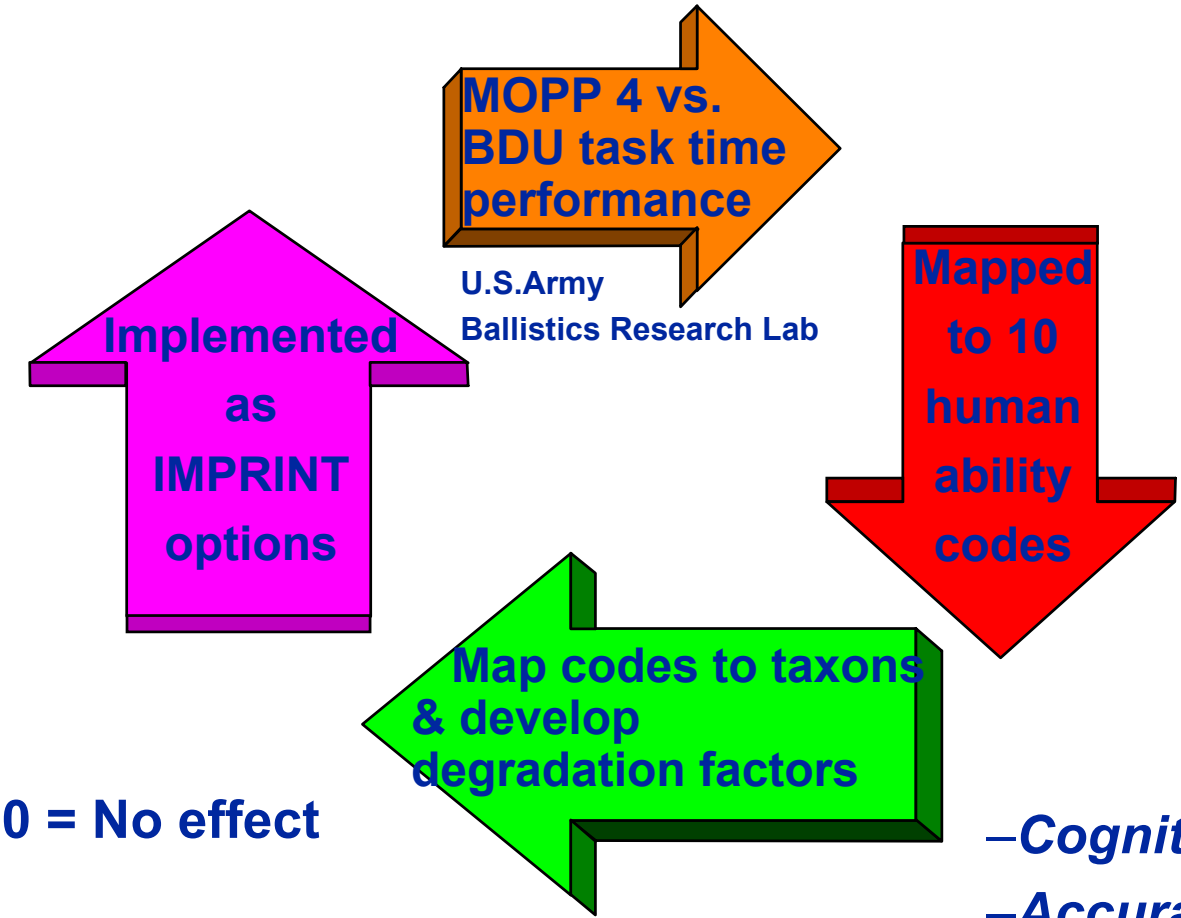
Applying Stressors

Stressor		Measures
Heat	→	Temperature & Humidity
Cold	→	Temperature & Wind speed
Noise	→	Distance & Noise level (dbs)
MOPP	→	Level (0 - 4)
Sleepless Hours	→	Hours since last slept

Environmental Stressors Screen



Development of MOPP Degradation Factors



–MOPP 0 = No effect

...

–MOPP 4 = Up to 1.7 X as long

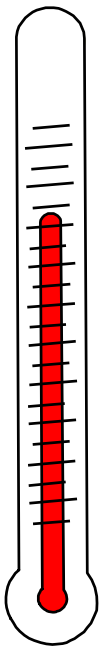
–Cognitive degradation?

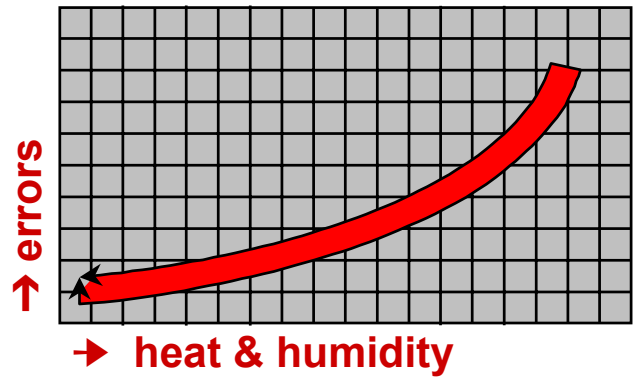
–Accuracy degradation?

–Work rate parameter?

Development of Heat Degradation Factors

- Heat degradation factors in IMPRINT derived from studies relating heat stress to inaccurate performance
  - » Bioastronautics Data Book, 1981
  - » Parker, 1973
  - » MIL-HDBK-759A

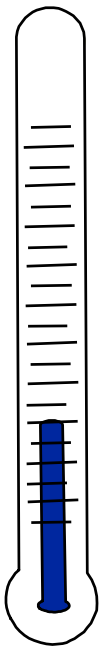


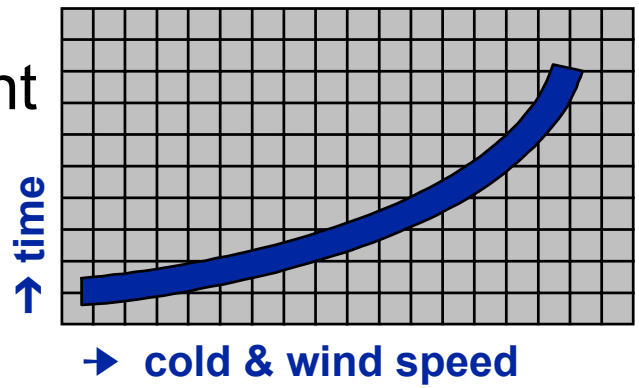


– *Additional parameters (work rate, clothing, etc.)?*

Development of Cold Degradation Factors

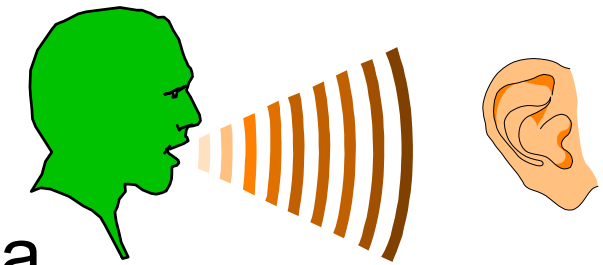
- Cold degrades task time as a function of ambient temperature and wind velocity
  - Derived from Teichner (1958) relating wind chill to % performance loss
    - » One for visual reaction time & fine motor discrete
    - » Another for gross motor light
  - *Assumes bare skin*
  - *Assumes linear degradation across decreasing temperatures*





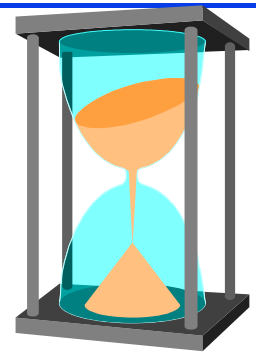
Development of Noise Degradation Factors

- Noise degrades task accuracy as a function of noise level & speaker-listener distance
  - Derived from Human Engineering Design Criteria MIL-STD-1472C

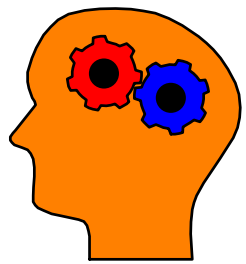


  - *Need to consider communication frequency & voice level*

Development of Sleepless Hours Degradation Factors



- Hours since last sleep degrades time & accuracy
  - Derived from a review of several studies
  - Cognitive performance is more sensitive to degradation than physical strength and endurance tasks
  - Decline in performance is roughly 25% for every 24 hours of operation



  - *Need degradation for non-cognitive work*

Stressor Update in Process...

- Hours since last sleep
  - IMPRINT too optimistic! Impact at < 24 hours
  - Does affect all taxons
- Circadian rhythm
  - Important stressor including interaction w/ sleep loss
  - Need time of day interface
- Nuclear, biological, & chemical
  - Exposure effects, type & time; need to map to IMPRINT taxons
- Vibration
  - Dimensions of vibration
- Noise
  - Does affect cognitive tasks
- Some empty cells in IMPRINT matrix are OK

Combining Stressors

Power Function

$$DF_T = \prod_{i=1,n} \sqrt[i]{DF_i}$$

Where:

DF_T = Total degradation factor

DF_i = The i^{th} degradation factor when when ordered from largest to smallest

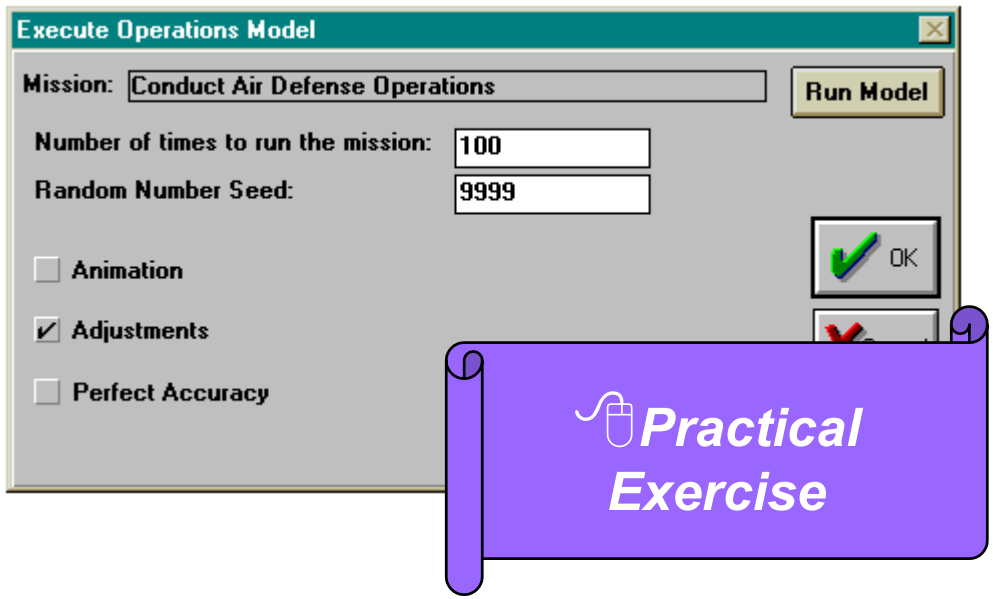
n = Number of degradation factors

Applying All PTS Options

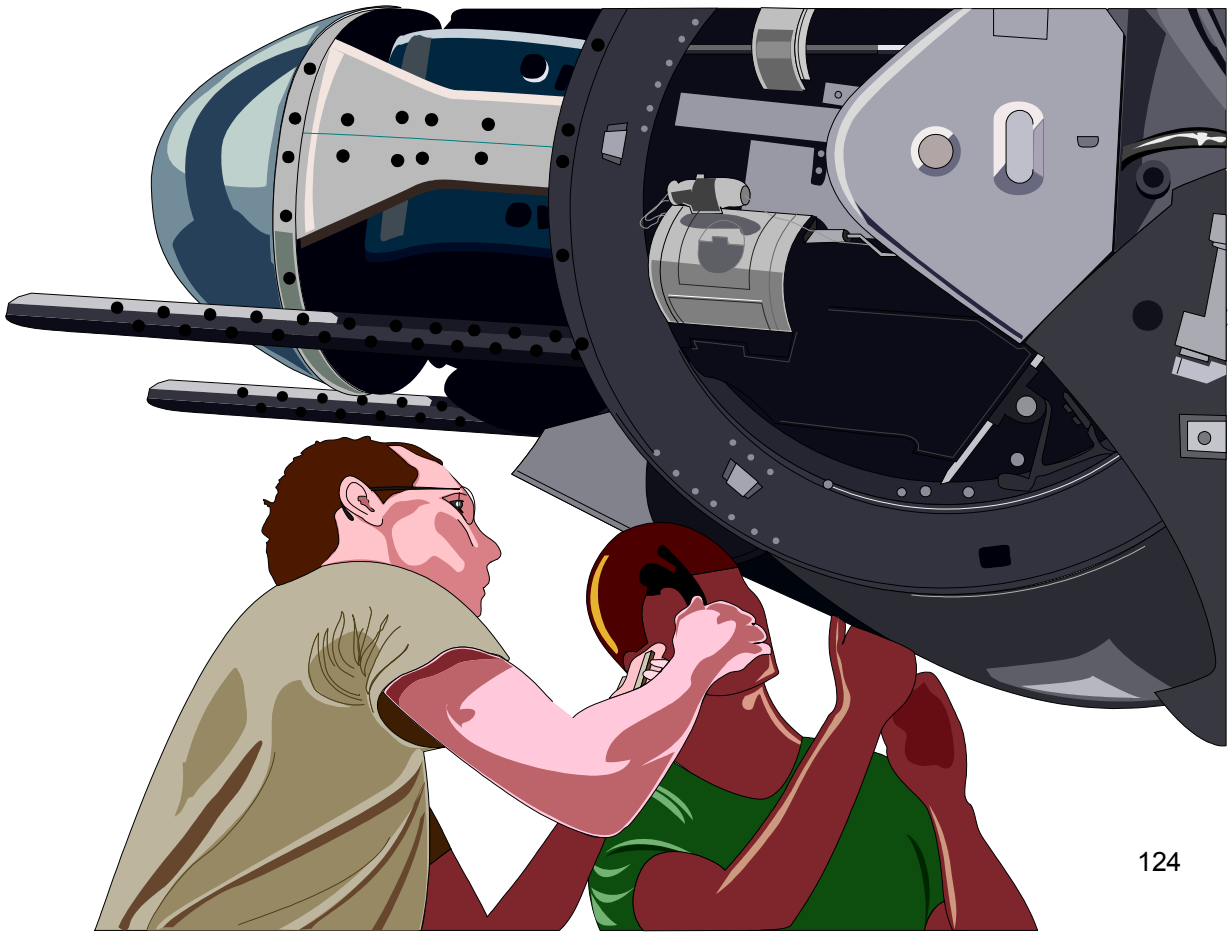
- First apply ***Personnel Characteristics***
- Then apply ***Training Frequency***
- Apply ***Stressors*** last

Running the Model with PTS Options

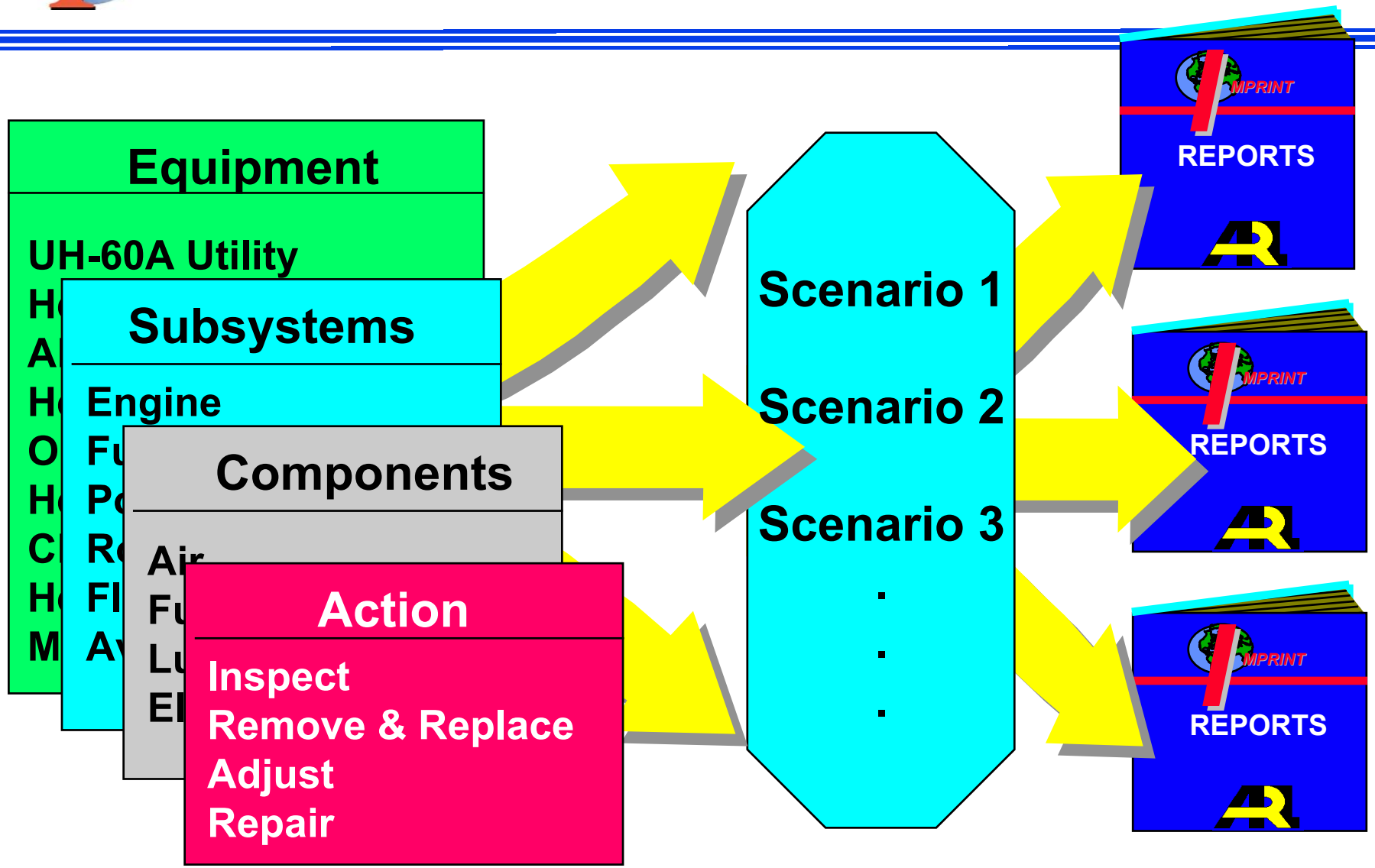
- Run baseline model first
- Apply PT and/or S
- Review effects by task
- Re-run model with Adjustments selected
- Compare outputs with baseline



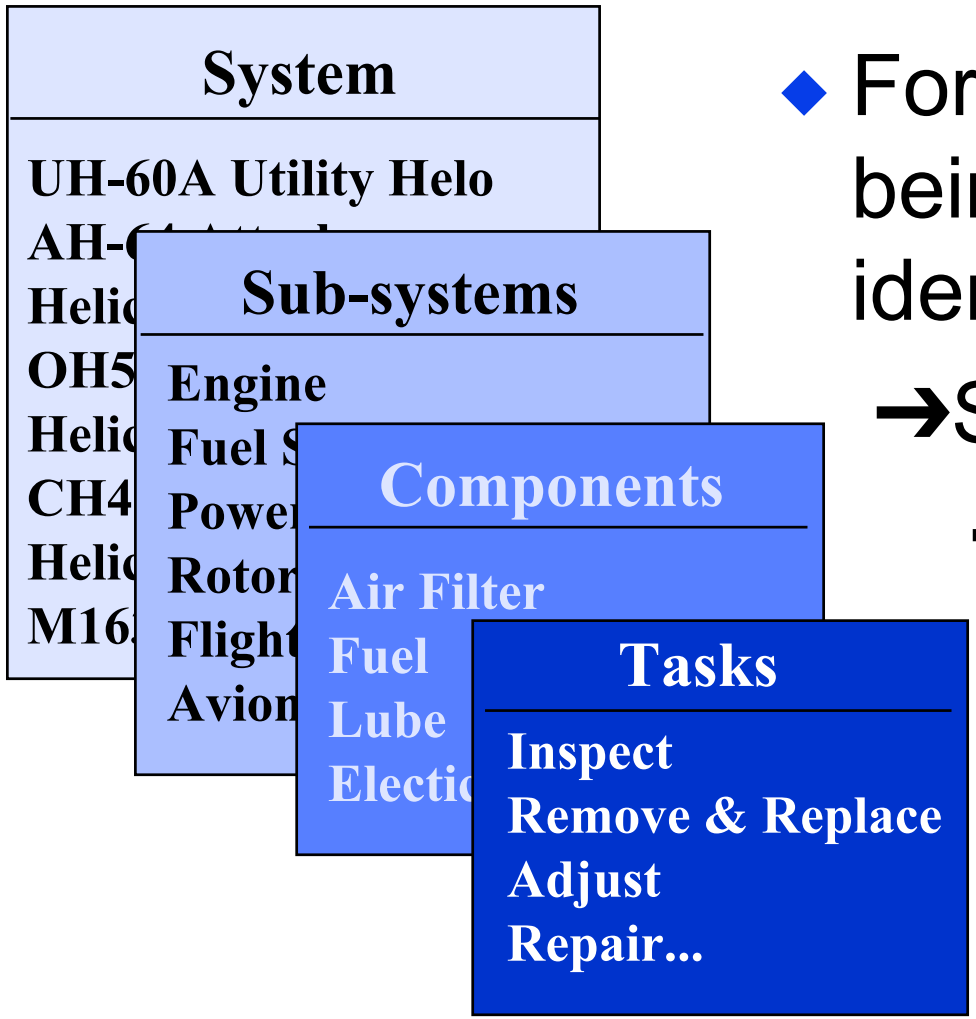
Define Equipment



Define Equipment Process



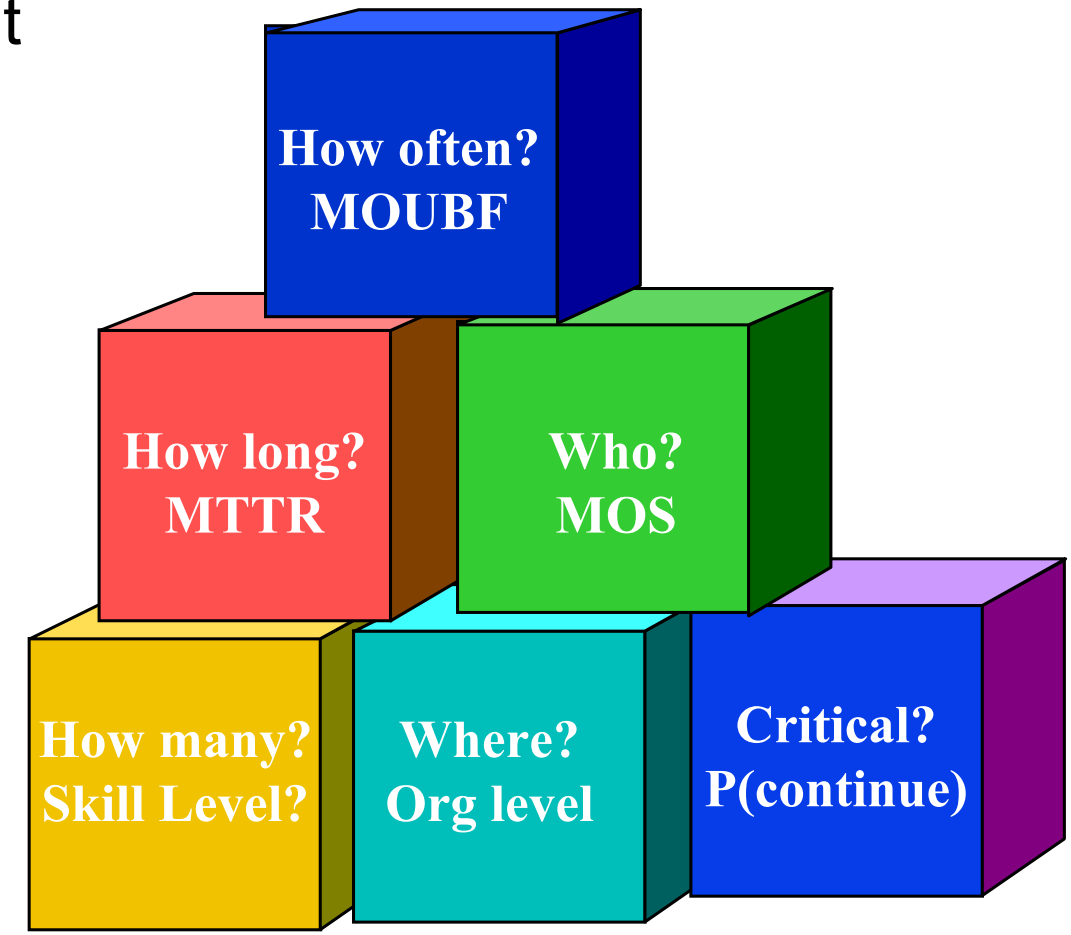
System-to-Task Decomposition



- For the system being modeled, identify
  - ➔Sub-systems
    - ➔Components
      - ➔Tasks which are either corrective or preventive

Maintenance Task Data

- Mean operational unit between failure (i.e., maintenance actions
- Mean time to repair
- Soldier job specialty
- How many of what skill level
- Organizational level
- Mission criticality



Scenario Elements

- System Operational Profile
- Maintenance Crew
  - Number & types of people available to do the maintenance on each shift
- Travel Time
  - Amount of time to get system to the people (or people to the system) on the battlefield
- Repair Parts
  - Likelihood a part is available
  - Average wait time, if not available

Operational Profile Data Items for Every Segment

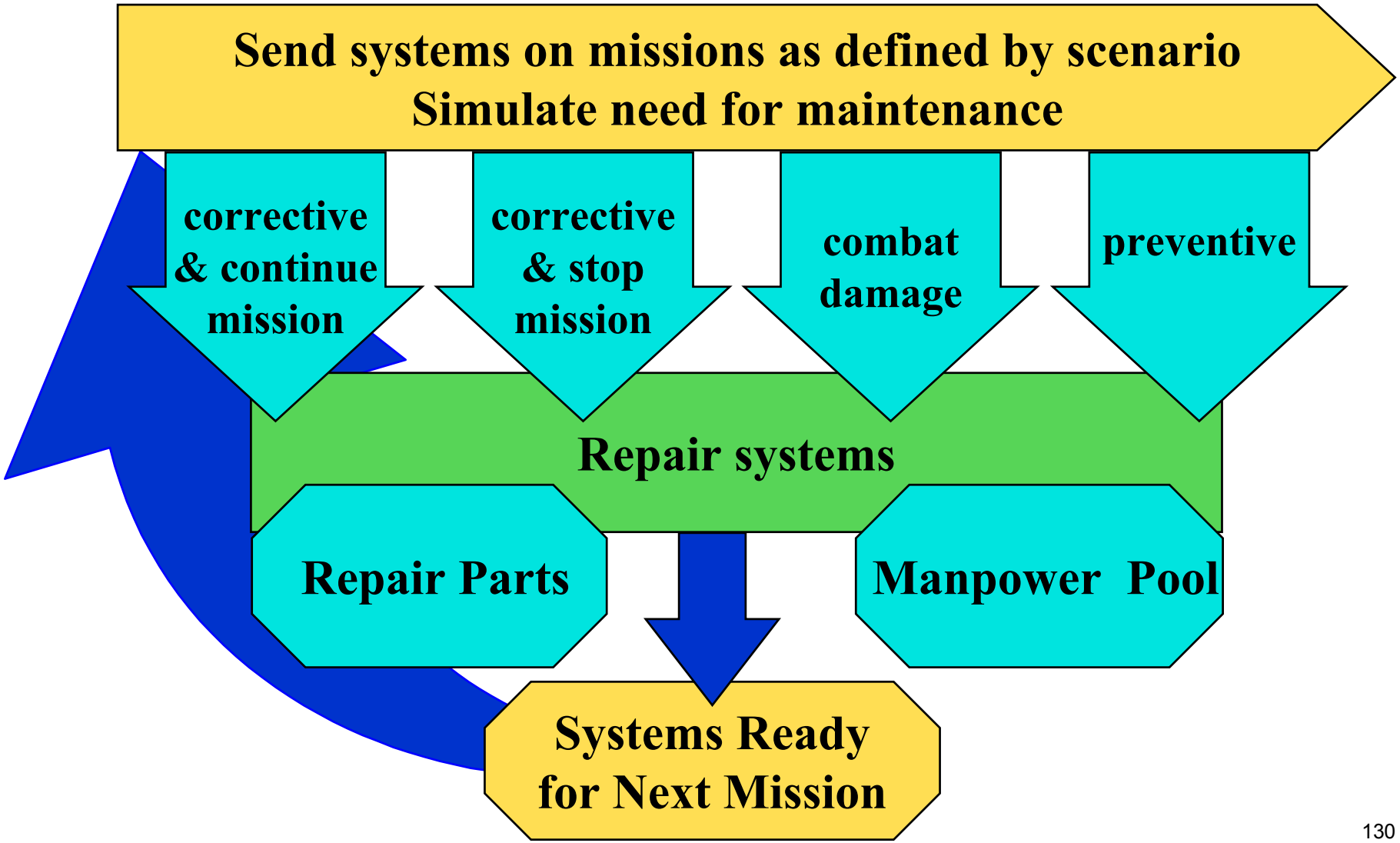
- Consumables (i.e., Usage) data
- Time & systems data
- Combat data

Distance traveled
Rounds fired
Load Time

Start time & day
Duration
Priority
Max and min # systems needed
Number of systems per mission

Probability of hit
Probability of kill
Replacement time

Stochastic Maintenance Model



Maintenance Model Reports

Detailed & Summary Measures

- Maintenance manhours by:
  - task, component, & sub-system
  - preventive & corrective maintenance
  - organizational level
  - soldier job specialty

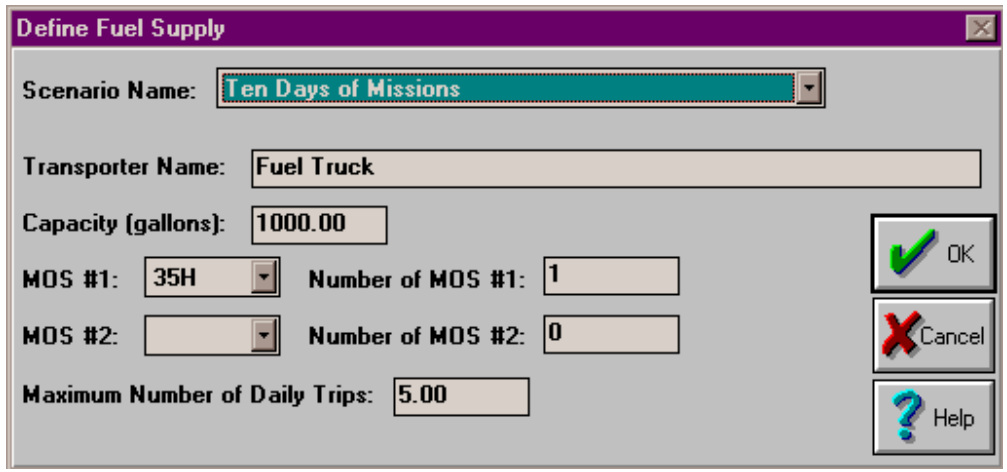
- Achieved operational availability & readiness
- Maintenance to operational hours ratio
- High driver subsystems
- Personnel utilization
- Logistics downtime
- Combat damage
- ...

Practical Exercise

Define Supply

Define Fuel Supply

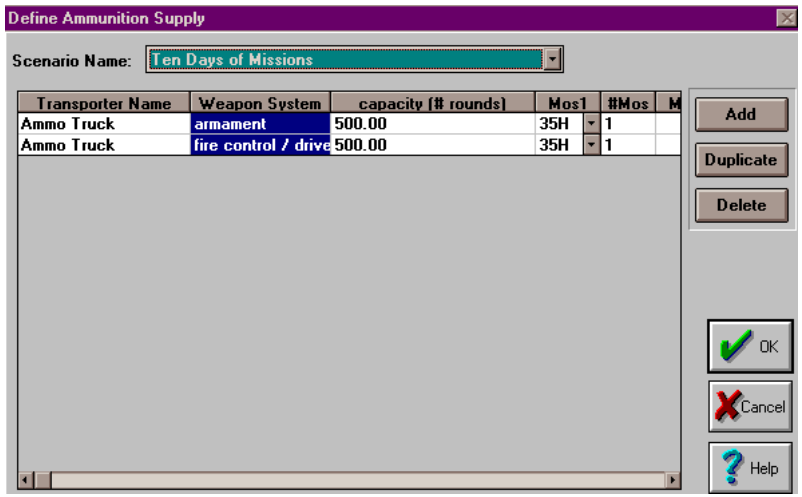
- Select a scenario created under Define Equipment



- Enter
  - Transporter name
  - Capacity of transporter in gallons
  - Manpower required
  - Maximum number of trips per day

Define Ammunition Supply

- Select scenario created under Define Equipment



- For each weapon system enter
  - Transporter name
  - Capacity of transporter in rounds
  - Manpower required
  - Maximum number of trips per day

Supply and Support Report

Supply Results

April 7, 2000

System M1 ABRAMS

Scenario 0 Ten Days of Missions

Subsystem	Transporter	Total#Trips Needed	Mos1	#Needed	Mos2	#Needed
armament	Ammo Truck	1.55	35H	0.31		0.00
fire control / drives	Ammo Truck	1.55	35H	0.31		0.00
Fuel	Fuel Truck	111.60	35H	22.32		0.00

Practical Exercise

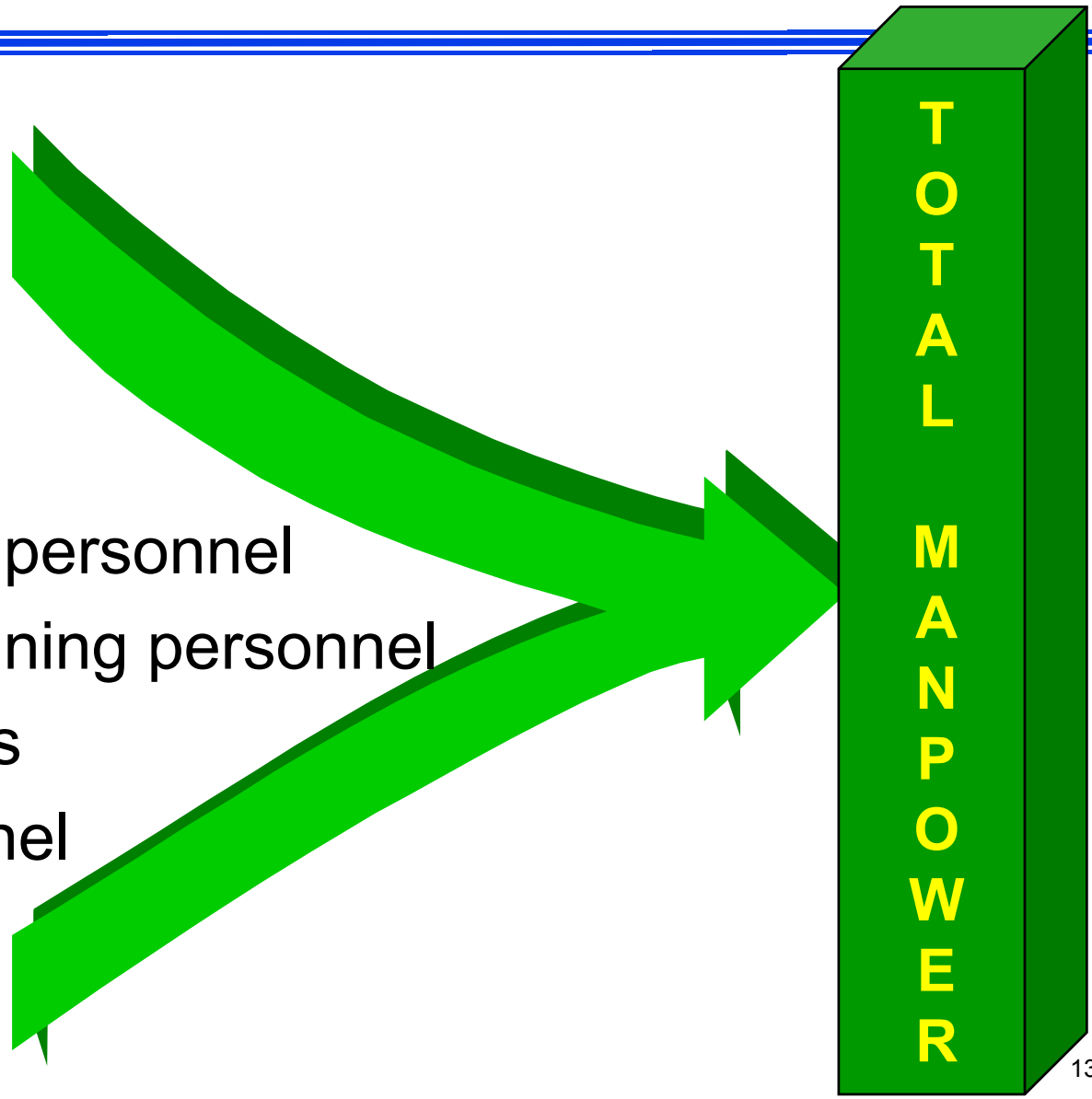
Define Force Structure

Define Force Structure

- Estimates of total “system driven” manpower
- Maintenance manpower based on Define Equipment
- Operator manpower based on crew size
- Development of a phasing schedule
- Adjustments for op tempo and MMHs

System-Driven Manpower

- ⇒ Operators
- ⇒ Maintainers
- ⇒ Fuel handlers
- ⇒ Transportation personnel
- ⇒ Institutional training personnel
- ⇒ Ammo handlers
- ⇒ Supply personnel



Maintenance Manpower

Specify unit type & size (e.g., tank battalion) in maintenance model

Specify number of systems in unit

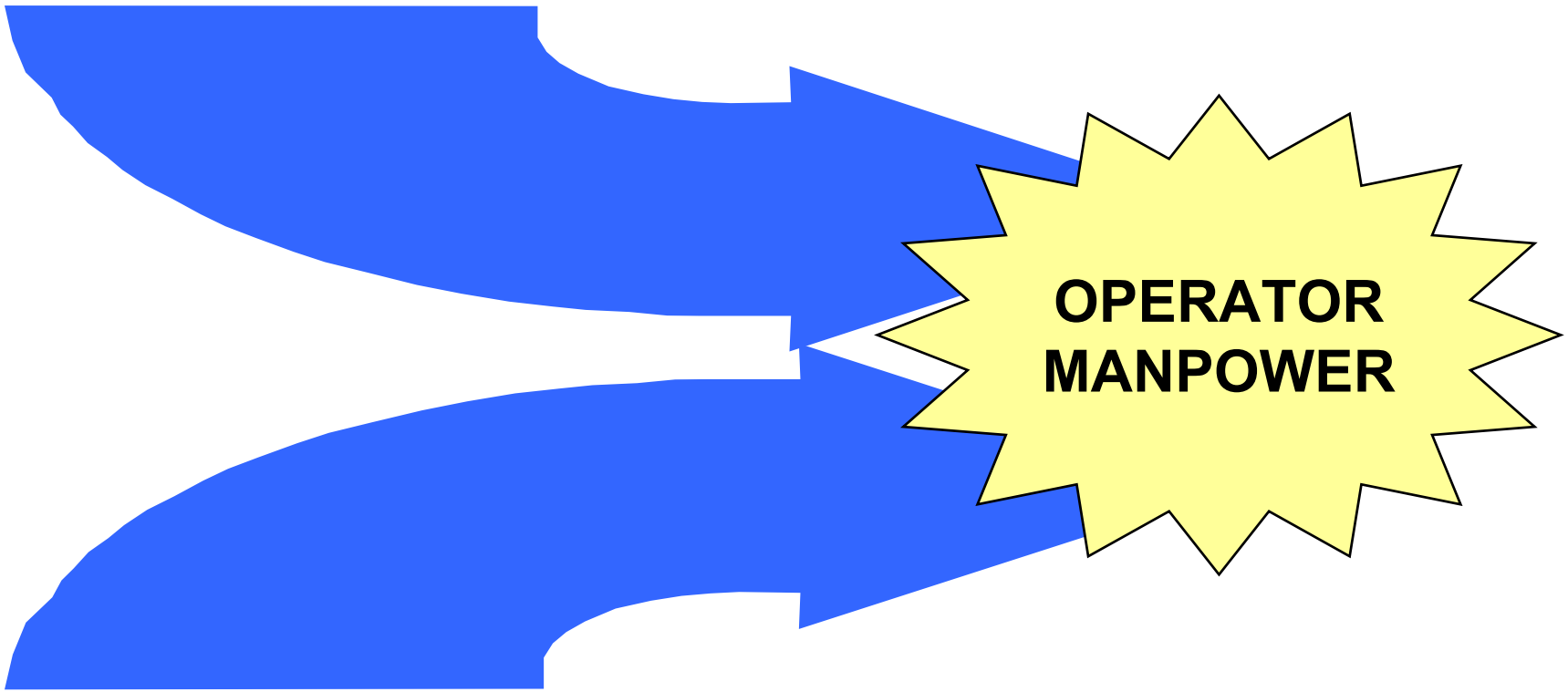
Specify scenario

Run model

MAINTAINER MANPOWER

Operator Manpower

Determine crew size in define mission



Specify crew ratio

Adjustments

- Adjust op tempo by major unit
- Adjust MMHs by maintenance level & unit

Reports

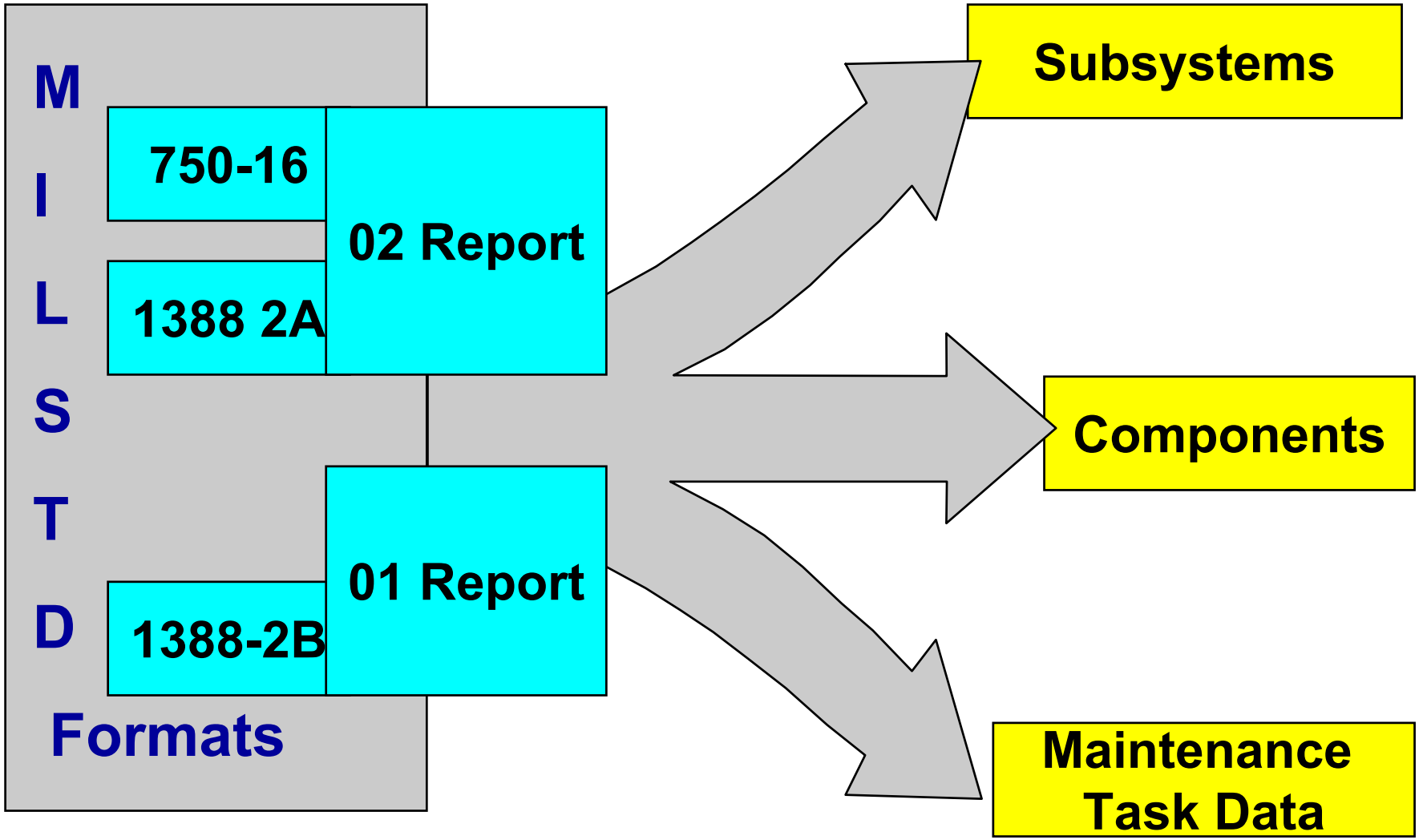
- Manpower Estimate
- Force Structure
- Manpower Requirements by Year
- Manpower Requirements by Unit

Other Features & Support...

Import and Export

- To other IMPRINT users…
  - Use Import Analysis and Export Analysis
    - » Analysis must be closed
- To Wincrew users…
  - Use Import Advanced Mission and Export Advanced Mission
    - » Analysis must be open
- To Micro Saint users...
  - Under Options, use Micro Saint Send Model and Micro Saint Retrieve Results
    - » Analysis must be open

LSA Import for Define Equipment

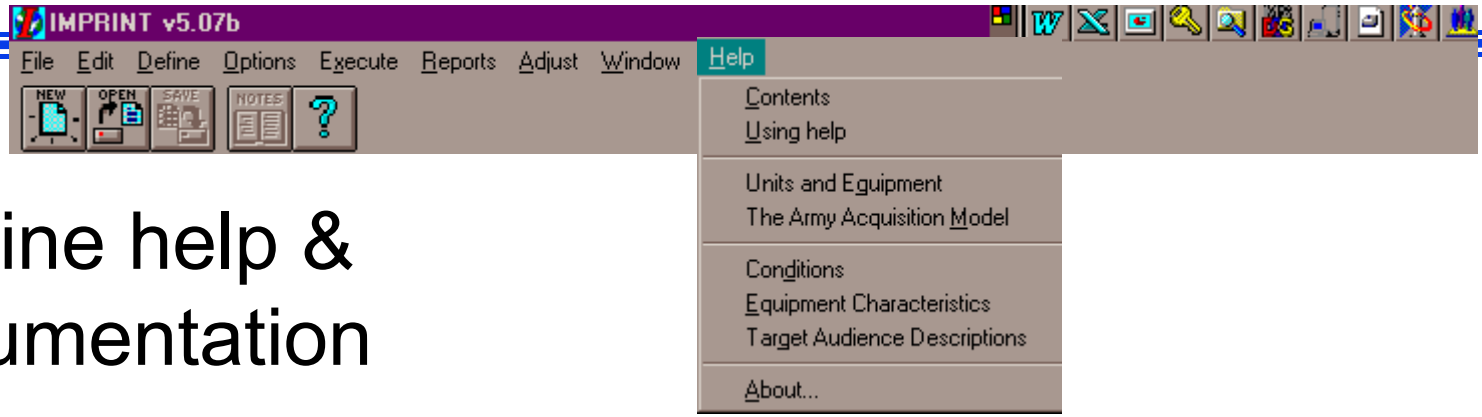


Mapping Workload to Taxons

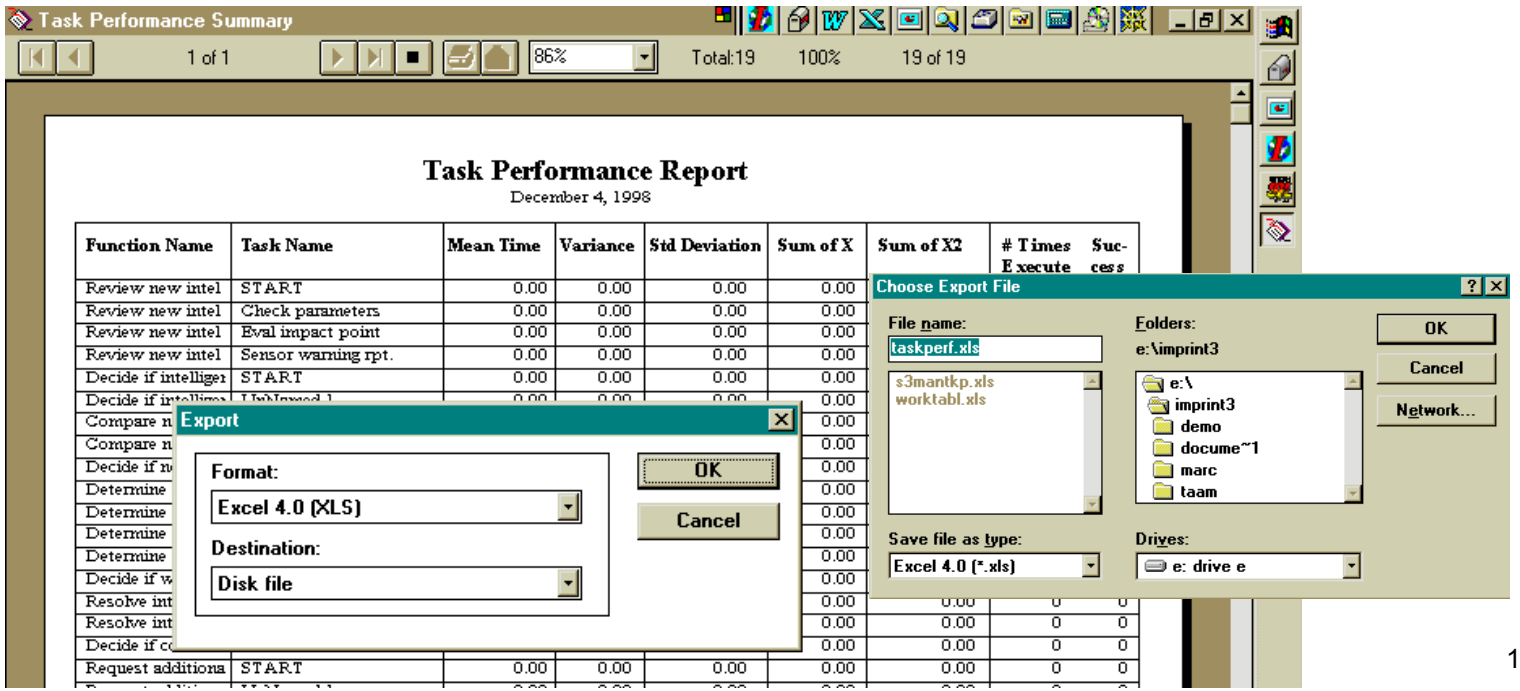
Mental Workload Ratings	Taxons
Visual 1.0, 3.7, 4.0, 5.0, 5.4, 7.0	Visual (Pattern Recognition-Discrimination)
Cognitive 7.0	Numerical
Cognitive 1.0, 1.2, 3.7, 4.6, 5.3, 6.8	Information Processing
Psychomotor 2.2, 4.6, 5.8, 7.0	Fine Motor Discrete
Psychomotor 2.6	Fine Motor Continuous
---	Gross Motor Light
---	Gross Motor Heavy
Auditory 4.9, 6.6, 7.0 Psychomotor 1.0	Communications (Oral)
Visual 5.9 Psychomotor 6.5	Communications (Read & Write)
Auditory 1.0, 2.0, 4.2, 4.3	---

*Note that none of the VACP workload scores map into either GML or GMH taxons because workload channels are primarily mental

More Features...



- On-line help & documentation
- Move reports to Word, Excel, etc.



Documentation & Analysis Support

- On-line help

Loaded in 'imprint/documentation' directory

- Analysis Guide
  - » goal statement
  - » results
  - » bounds/limits/mental model
  - » data needs
- User's Manual
  - » definitions, glossary
  - » error list and types (e.g., msaint, Windows)
  - » duplicate on-line help
  - » data sources
  - » taxon / stressor effects

Getting the Software

Who

- Any government agency
- Private industry with government contract
- Foreign government (case-by-case)

How

- Send request via e-mail or letter
- If private industry include government contract number and organization

Non-Distribution Form

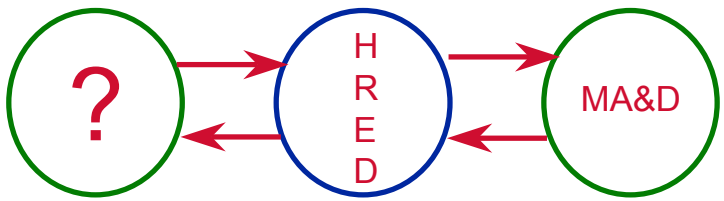
- Keep track of users
- Reminder not to distribute

Software Distribution

Technical Support

ARL-HRED

- Mr. John Lockett (jlockett@arl.army.mil)
  Phone - (410) 278-5875
- Ms. Celine Richer (cricher@arl. army. mil)
  Phone - (410) 278-5883
- Ms. Diane Mitchell (diane@arl. army. mil)
  Phone - (410) 278-5878
- Ms. Jody Wojciechowski (jqw@arl.army.mil)
  Phone - (410) 278-8830
- Ms. Charneta Samms
  Phone - 410-278- 5877



Maintain Database

- User comments
- “Bugs”
- “Fixes”

Using the List Server

- List of current IMPRINT users & interested parties

- Send suggestions, comments, general information or questions regarding IMPRINT to

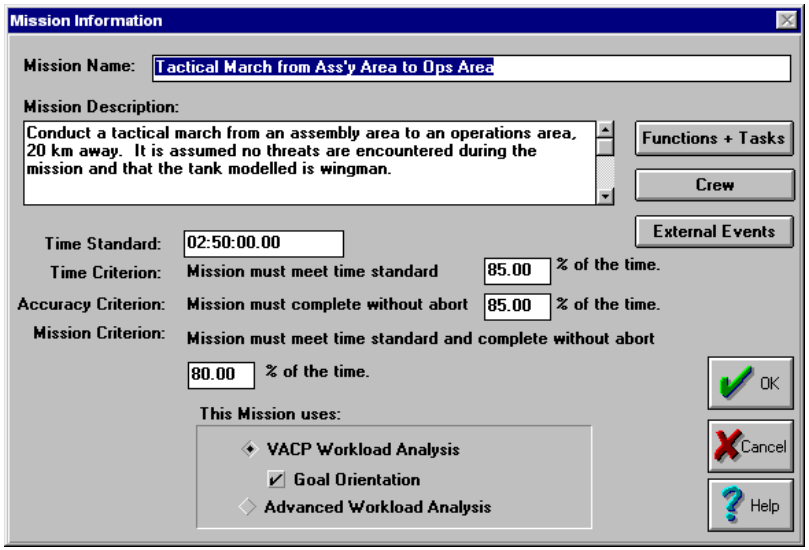
imprint@shred.arl.army.mil

Future Capabilities!

Version 6 Capabilities

- Goal orientation
  - Option from VACP
  - Beginning & Ending Effects
  - Variable Catalog
  - Macros (User-Defined Functions)
  - Snapshots
- COM capabilities
  - Including HLA Middleware
- Access to tag
- Check syntax
- Better memory management

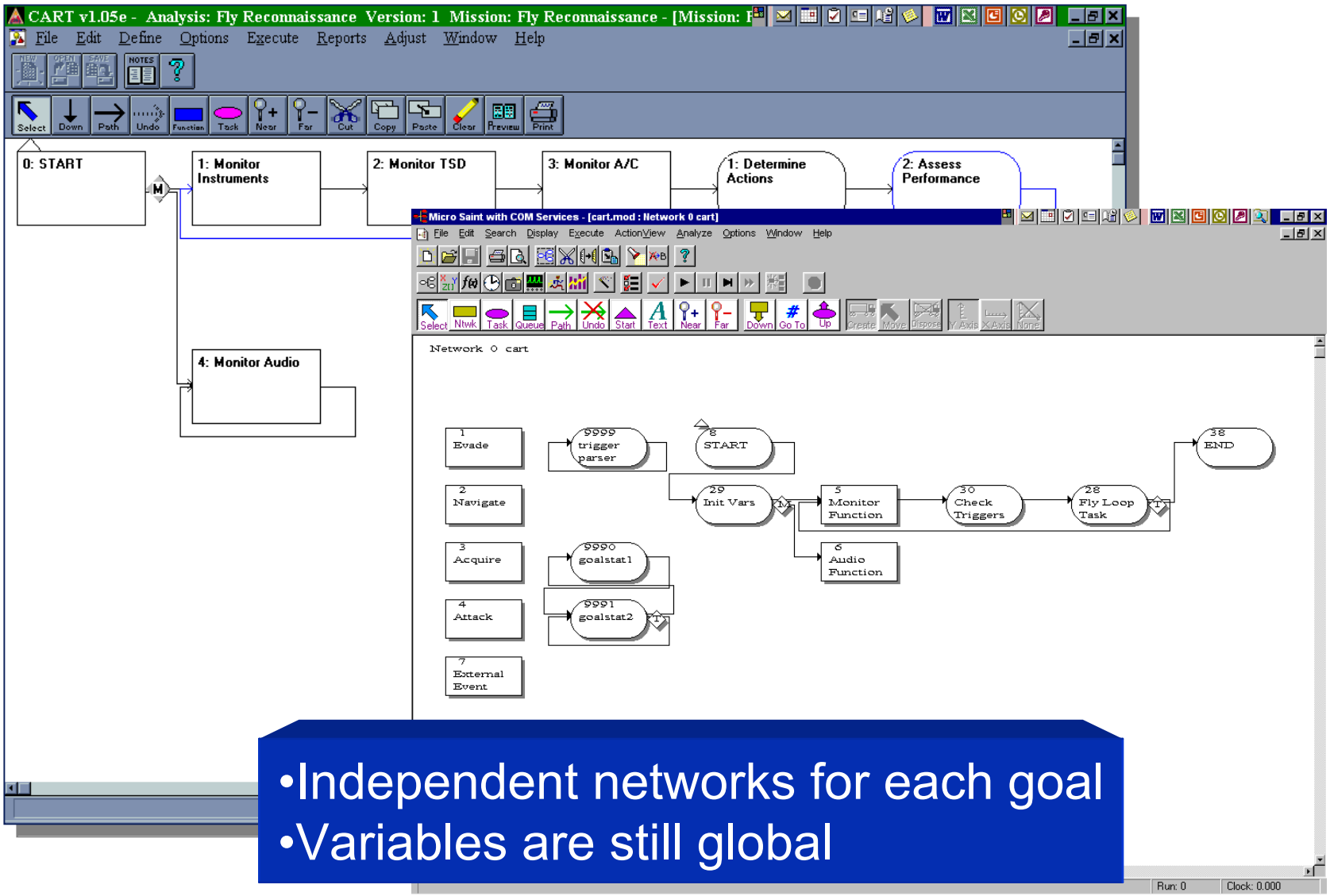
Version 6



- VACP
- Beginning/Ending
- Release Conditions
- Variable Catalog
- External Events
- Goal Functions
- Interrupts
- Advanced Fail Effects

VACP-Advanced “Mutation”
Will work on existing models BUT
multiple decisions don’t automatically rejoin!

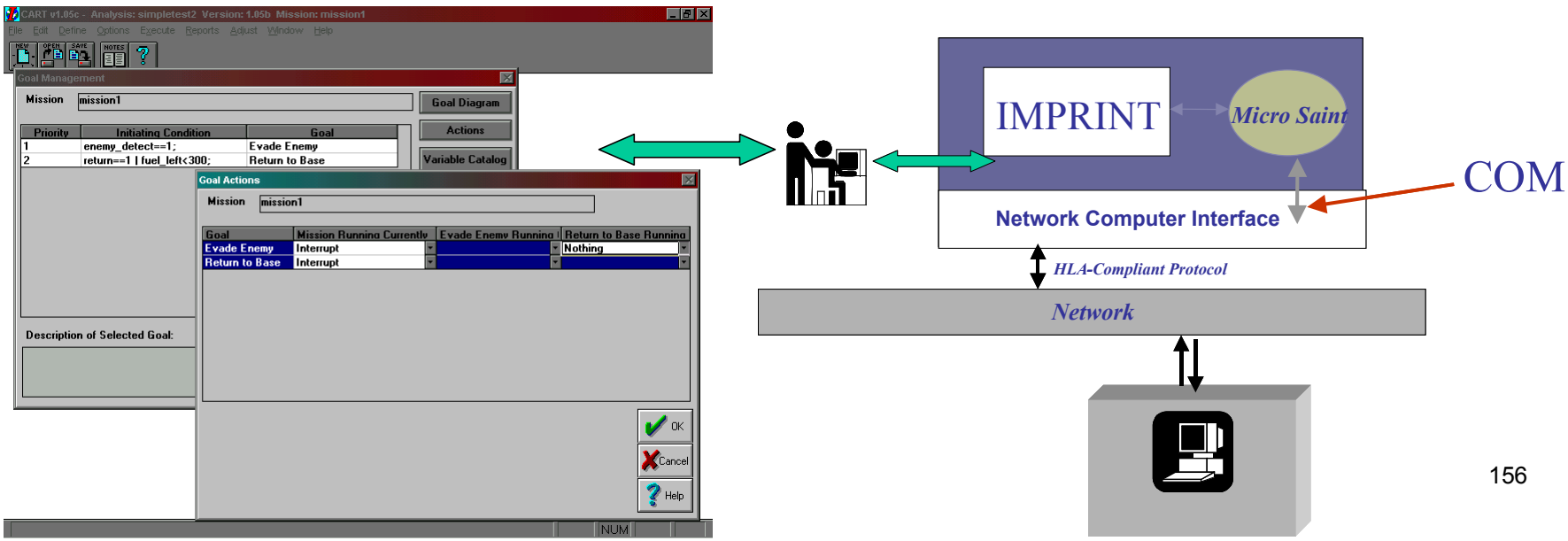
Task Network Model Development

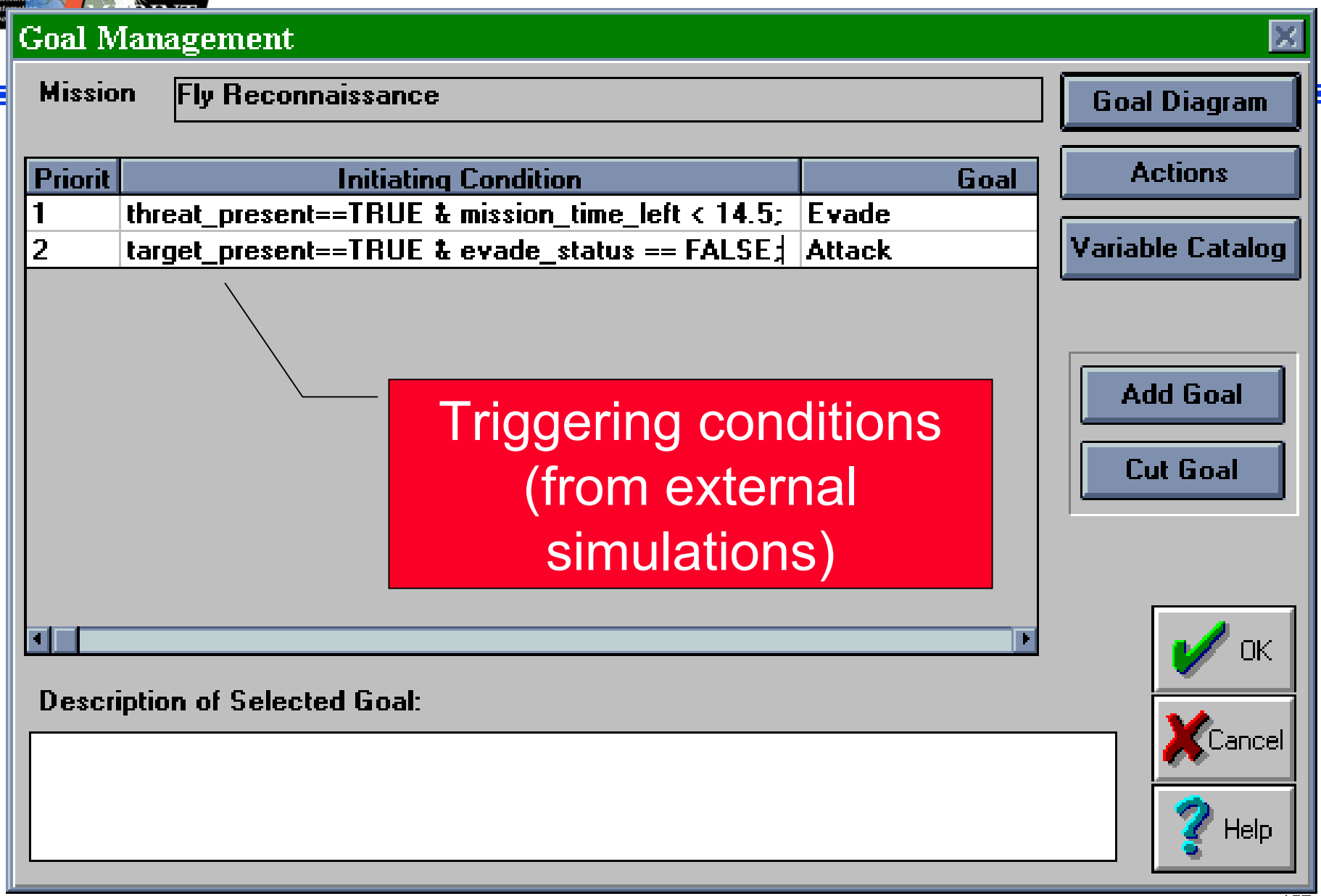


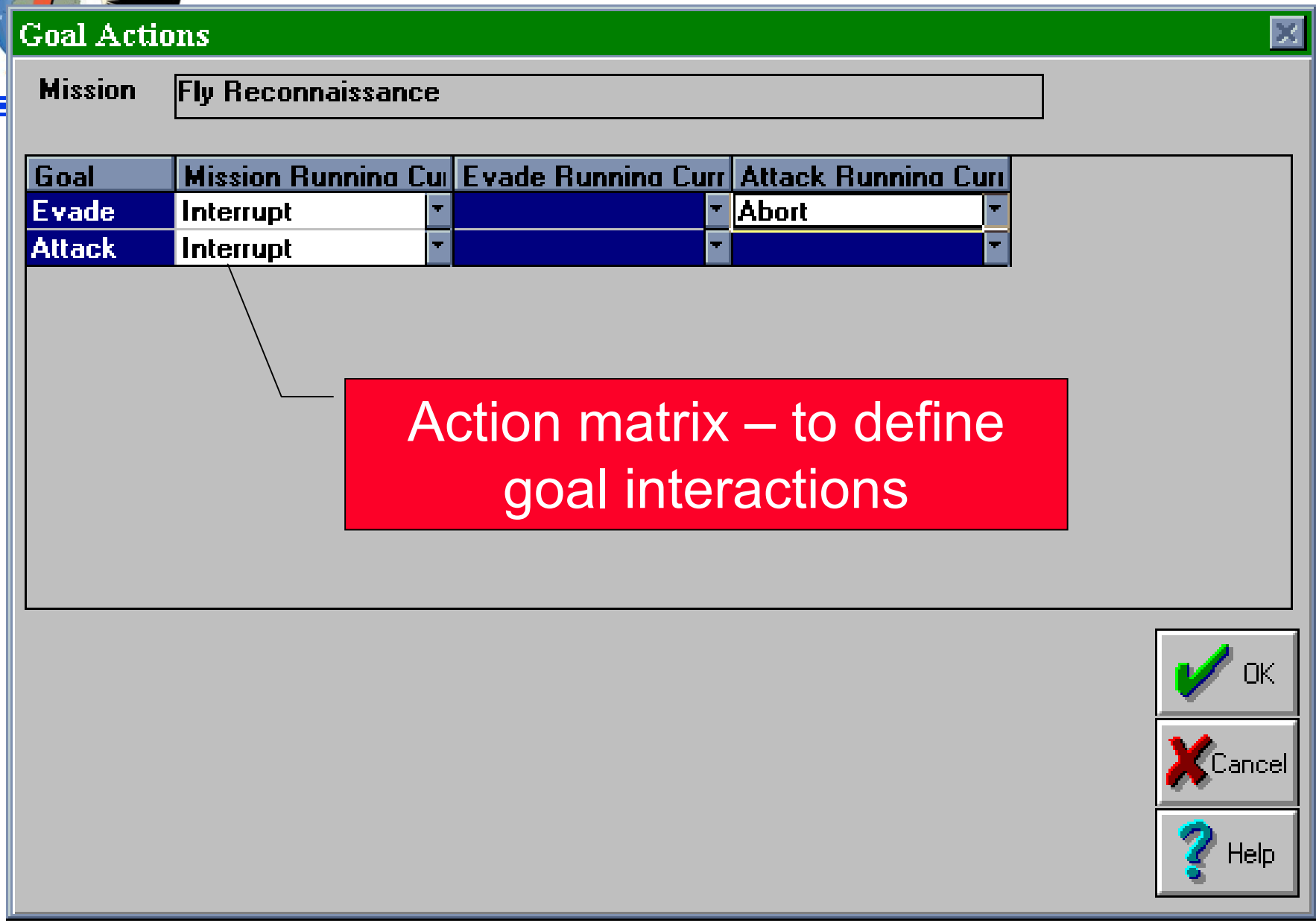
- Independent networks for each goal
- Variables are still global

Innovations

- Trigger identification
- Trigger communication
- Task interruption
- Task restart vs. task resume




Goal Management
Mission
Fly Reconnaissance
Goal Diagram
Actions
Variable Catalog
Priorit
Initiating Condition
Goal
1
threat_present==TRUE & mission_time_left < 14.5;
Evade
2
target_present==TRUE & evade_status == FALSE;
Attack
Triggering conditions (from external simulations)
Add Goal
Cut Goal
Description of Selected Goal:
OK
Cancel
Help


Goal Actions
Mission
Fly Reconnaissance
Goal
Mission Running Cu
Evade Running Curr
Attack Running Cur
Evade
Interrupt
Abort
Attack
Interrupt
Action matrix – to define goal interactions
OK
Cancel
Help

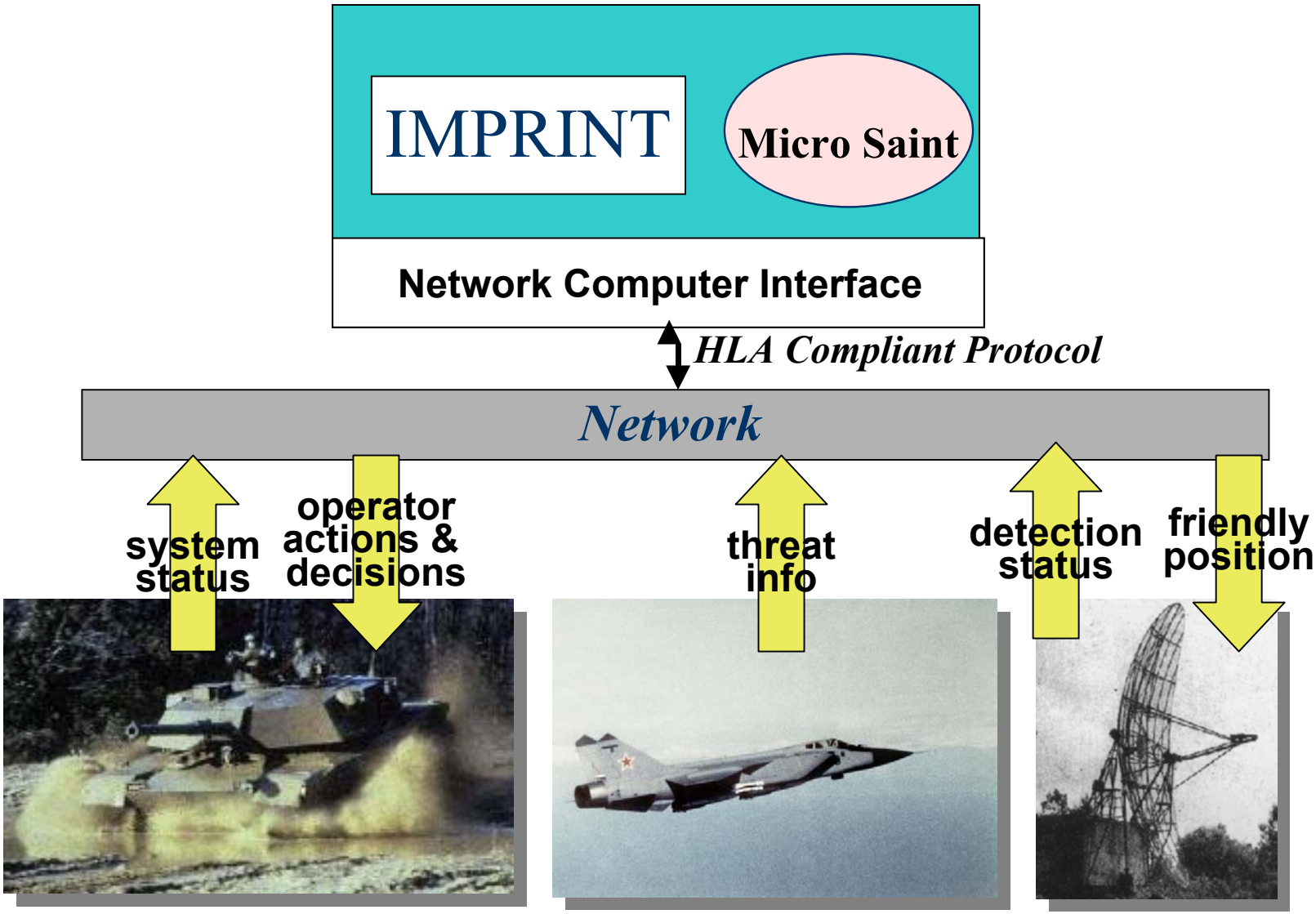
Goal Rules

- When a trigger comes true:
  - Look UP the matrix to see if a higher priority goal would suspend or halt it. If so, don't start it, but keep trying. If not:
  - Look DOWN the matrix and implement the actions for all lower priority goals
- When a goal ends normally, gets halted or gets suspended:
  - Resume anything it suspended UNLESS a higher priority goal would halt it. If so, halt it. If a higher priority goal would suspend it, then suspend it.

Variables of Interest

- curgolstatus[goalid], curtskstatus[taskid]
  - 1=running, 2=suspended, 3=halted, 4=ended
- goalparent[taskid]
- action[goalid, goalid]
  - 0=nothing, 1=interrupt, 2=halt, 3=start
- mission has a goalid of 0
- task() is Micro Saint task number

System Architecture



News of Note

- AF Validation Success Story
  - Wright Pat SIMAF Virtual Strike Warfare Environment
  - Time critical targeting (SCUD Hunt) mission
  - HPM vs. Eight pilots (F16 and A10)
  - overall kills of ground targets in the time critical scenario was virtually the same for both the model and pilots (100% and 98%, respectively)
  - HPM accounted for 61 percent of the behavior of the pilots in the simulation environment
  - New tactic discovered: Coordinated use of synthetic aperture radar (SAR) and targeting infrared (TIR) imaging system

Wrap-Up Discussion & Thanks for Coming!

References

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